

ORDOVICIAN TRILOBITES OF THE FAMILY TELEPHIDAE AND CONCERNED STRATIGRAPHIC CORRELATIONS

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INTRODUCTION

Previous work on Telephus.—The genus *Telephus* was established by Barrande² for the Bohemian species *T. fractus*. Of this species Barrande knew only the cranidium and the pygidium, and of the former he mistook the long palpebral bands for the border of the cheeks. Consequently he expressed himself as quite unable to place the genus in his classification of the trilobites. Two years later Angelin³ described three species from Ordovician formations in Norway and Sweden but added nothing toward fixing the systematic position of *Telephus*. Some years later Billings⁴ recognized the genus on the west side of the Atlantic but, like his predecessors in the field, failed to add anything of more than specific importance to what had been known before. Many years later Reed⁵ described a cranidium from the Girvan District in Scotland that he regarded as specifically identifiable with the Bohemian *T. fractus*. In 1909 he described a new species, *T. hibernicus*, from an Ordovician formation in Ireland, and five years later⁶ in the supplement to his mono-

¹ This is one of many papers on trilobites for which the author has worked out the facts in the past 25 and more years but lacked the time to complete the manuscripts and illustrations. Most of these unpublished works endeavored to present what was known at the time of the species of a particular genus or family. At the earnest and repeated solicitation of friends it is now planned to bring to date and publish as many of these old manuscripts as possible without interfering too greatly with the paramount duty of completing the long promised monographs on the Ozarkian and Canadian systems. The present installment has become possible mainly through the gratefully accepted aid of Dr. C. E. Resser, who made most of the photographs and assisted otherwise in promoting the effort. The originally brief discussion of the stratigraphy of the beds in which species of *Telephus* occur has been greatly expanded and completely rewritten, so that in the writer's opinion it has become the more important part of the paper.

² Barrande, Joachim, 1852, Syst. Sil. du centre Boheme, vol. 1, p. 890.

³ Angelin, N. P., 1854, Palaeontologia Scandinavica, p. 91.

⁴ Billings, E., 1865, Paleozoic fossils: Canada Geol. Survey, vol. 1, p. 291.

⁵ Reed, F. R. Cowper, 1903, Paleontogr. Soc., p. 44.

⁶ Reed, F. R. Cowper, 1909, Geol. Soc. London Quart. Journ., vol. 65, p. 149; 1913, Paleontogr. Soc., vol. 67, p. 16.

graph he described another new and very different species (*T. salteri*), from the Balclatchie group of Scotland.

Except Barrande none of the mentioned authors even discussed the generic relations of *Telephus*. The first to give us anything like a true estimate of these relations was Hadding,⁷ who, in a paper specially devoted to the species of *Telephus* known in 1913, supplied much desired information concerning the palpebral lobes, eyes, and free cheeks. On the basis of these new data he endeavored to show the previously unsuspected relations of the genus to the Aeglinidae, on the one hand, and the Remopleuridae, on the other. Still, he found sufficient differences to convince him that *Telephus* represents a family of its own.

In 1905 I found my first cranidium of a *Telephus* in the Appalachian Valley. It and others procured at the same time were found in a dark subcrystalline limestone—on Reservoir Hill, near Lexington, Va.—that is now known to represent the Whitesburg limestone⁸ of Tennessee. The outcrop near Lexington was discovered some years before and recommended to me as containing an abundant and at that time strange fauna by Prof. H. D. Campbell of Washington and Lee University. During the course of my stratigraphic work in the Appalachian Valley since 1905 many other occurrences of *Telephus* were found in southwestern Virginia, Tennessee, and Alabama. Most of these were in the horizon of the Whitesburg limestone which, when present at all, lies just beneath the base of the Athens shale and in places rests on the Holston marble. In Virginia the latter was known for a time by the now unnecessary name Murat limestone. Above the Whitesburg the genus is represented by five species in the Athens shale and by three other species in the next overlying Tellico formation.

Character of material.—As in Europe and Canada the southern Appalachian species of *Telephus* also are represented mainly by cranidia. No complete specimens have been found, and the separated free cheeks, pygidia, and thoracic segments that were observed are surprisingly few. Moreover, the descriptions of the cranidium given by Barrande, Angelin, and Billings misled us as to the nature of

⁷ Hadding, Assar, 1913, *Släklet Telephus*: Geol. Fören. 1 Stockholm Förel., pp. 25-48.

⁸ The term Whitesburg limestone has been used by me for many years and is now formally proposed for the dark crystalline limestone that at many places in the Appalachian Valley south of Staunton, Va., underlies the dark calcareous Athens shale or limestone. At most places in the valley the Whitesburg rests on the Lenoir limestone, but at Lexington and in the belt that runs along the west base of Walker Mountain just east of Bland, in Virginia, the Holston marble lies between the Whitesburg and the Lenoir. The type-locality of the Whitesburg is at, and particularly 2 miles southeast of that town, and 1½ miles southwest of Bulls Gap, Tenn. At the latter place the formation attains a thickness of about 500 feet and rests on the Lenoir. Northwest of Whitesburg the formation pinches out completely in 2 miles. A large and distinctive fauna aggregating about 100 species has been collected from the Whitesburg.

the cheeks and eyes, so that it was only after satisfying myself regarding the free cheeks that belonged to each of the associated trilobites that the few unassigned remaining cheeks began to be considered as probably belonging to *Telephus*. It was in the occasional brief periods of 1908 to 1913 that could be devoted to the study of the Appalachian Ordovician faunas that I worked out the characters and wrote most of the following descriptions of the American species of the genus. Then before my paper could be completed and published Hadding's work on the genus appeared. Though his paper interfered with my slowly maturing plans and delayed publication of my results I am not sorry because so far as it went I know that Hadding's paper was a better contribution to the subject than mine at that time would have been. On the contrary, I was pleased to note that in all essential respects our conclusions were in accord. As regards structural features I differed then and differ now from his view of the two downwardly directed anterior spines, which he claims "are only parts of the cephalic limb intersected by the facial sutures." Possibly this is true of the European species studied by him, and on first sight it appears so also in the American species. However, on closer investigation I found that in all of the latter these are actually hollow spines with subcircular cross-section and separated at their bases by a depression or cleft from a much shorter prominence or angle of the rim against which the inner end of the free cheek abuts. This condition is clearly shown not only by a hundred or more of my specimens but equally well also in the types of *T. americanus* Billings. Text figures reproduced from drawings of a plaster cast of the best of the latter are given in Hadding's paper, but regarding these I can say only that the draughtsman for some unknown reason overlooked the separateness of the spines which is clearly indicated on at least the right side of the specimen (see pl. 2, fig. 23). Under the circumstances I am persuaded that the apparent difference between the American and European species rests on imperfect observation.

REVISED DESCRIPTION OF GENUS TELEPHUS

With the data now in hand the following amended definition of the genus is presented.

Family TELEPHIDAE Angelin

Genus TELEPHUS Barrande

Small, strongly convex and probably slender opisthoparian trilobites, with narrow pleural parts well separated from the relatively wide axis; carapace known only from dismembered parts. Cephalon

usually considerably wider than long, large as compared to the thorax and pygidium, with very large, often bulbous, eyes and narrow rim. Glabella well defined, usually strongly convex, tapering more or less forward, rarely semielliptical to subovate, without lateral furrows but in some species with a dimple near the middle of the lateral slopes and more rarely with smooth ovately outlined spaces that probably represent the posterior and second glabellar lobes of other trilobites. Occipital ring well developed, often crescentic, usually with a median spine that varies greatly in length and strength with the species. Fixed cheeks rather narrow posteriorly, increasing in width anteriorly so that the greatest width is more or less in front of the middle and the outline varies from crescentic to rounded-triangular; outer border made by a concave palpebral band that flattens along the anterior side beyond the eye; area between this band and the dorsal furrow more or less strongly convex, usually rising into a curved ridge. Posterior portion of facial suture directed obliquely outward, backward, and downward around the very small posterior limb to the point only a short distance from the dorsal furrow at which it cuts the posterior margin. Anterior part of facial suture beyond the eye closely following the anterior edge of the cephalon to a small projection of the rim which it cuts to reach the edge. Between these slightly projecting points the anterior rim is emarginated and the excavation divided unequally into three concave parts by two hollow spines that are highly characteristic. These spines sometimes project directly forward, but more commonly they curve gradually or more abruptly downward. The cavities on their outer sides are smaller than the median emargination and as a rule partly bottomed by shell. Free cheeks consist mainly of very large bulbous or somewhat crescentiform eyes separated on the outer side by a narrow deep groove from a narrow wirelike rim that broadens more or less near or somewhat in front of the middle of its posterior half to give sufficient lodgment for the base of a genal spine. This spine varies greatly in size and direction. Rarely it is weak and short, oftener strong, long and curved and directed outward at varying angles; and in one case it rises directly upward from the rim and curves over the eye. Occasionally a smaller though otherwise similar spine occurs a short distance behind the genal spine. The eyes, as said, are very large and more or less strongly convex, and numerous facettas as in *Aeglina*, and in some cases at least must have been set on the head so that in a dorsal view of the animal the outer rim of the cheek would be almost covered by the periphery of the eye. In such cases the genal spines are very small or wanting, as in *T. mysticensis*, or they are turned up beside and doubtless beyond the top of the eye, as in *T. pustulatus*. Facettes on eyes ar-

ranged in quincunx, varying greatly in size and number, in some as few as 15 transverse rows, in others as many as 50 rows between base and top of eye.

Thorax with broad axis, well defined dorsal furrows, and narrow pleural areas; axial part of segments each with a single or two closely approximated short, backwardly directed nodes or spines; pleural part of segments grooved, outer extremity more or less acuminate. Number of segments unknown.

Pygidium small, subtriangular to subpentagonal; axis strongly convex, sharply defined, wide in front, tapers rapidly and extends nearly to the posterior extremity; pleural lobes narrow, practically unsegmented; axis with two, rarely three, rings, all with one or two median spines, the second and third usually with a small post-lateral node on each side. General appearance of pygidium varies considerably in different species, the difference being in details rather than essential respects. The posterior edge may be simply rounded or drawn out into a flat median spine.

Genotype.—*Telephus fractus* Barrande.

Stratigraphic range.—Ordovician and earliest Silurian.

Origin and center of dispersal.—Middle Atlantic realm.

Geographic distribution as in the following tabulation of species:

GEOGRAPHIC DISTRIBUTION AND STRATIGRAPHIC POSITION OF SPECIES OF TELEPHUS

European species

Telephus fractus Barrande, Bohemia, D 4 and D 5. •

Telephus granulatus Angelin, Norway and Sweden, upper half Ogygiocaris shale.

Telephus bicuspis Angelin, Norway and Sweden, lower half Ogygiocaris shale.

Telephus haddingi, new species, Sweden, lower half Ogygiocaris shale.

Telephus wegelini Angelin, Sweden, Trinucleus shale.

Telephus mobergi Hadding, Sweden, base of Ogygiocaris shale.

Telephus linnarssoni, new species, Delarne, Sweden, Leptaena limestone.

Telephus hibernicus Reed, Ireland, Tourmakeady Beds.

Telephus reedi, new species, Girvan District, Scotland, Whitehouse group.

Telephus? salteri Reed, Girvan District, Balclatchie group.

American species

Telephus americanus Billings, Newfoundland. Div. N and P.

Telephus mysticensis, new species, Mystic, Quebec, probably Blount age.

Telephus mysticensis simulator, new variety, Mystic, Quebec, probably Blount age.

Telephus bicornis, new species, Bland County, Virginia, Whitesburg limestone.

Telephus gelasinosus Ulrich, Pratts Ferry, Alabama, Whitesburg limestone.

Telephus pustulatus, new species, Lexington, Virginia, Whitesburg limestone.

Telephus latus, new species, near Saltville, Virginia, Athens shale.

Telephus spiniferus, new species, near Saltville, Virginia, Athens shale.

Telephus spiniferus calhounensis, new variety, Calhoun, Tennessee, near top of Athens.

Telephus sinuatus, new species, Lexington, Virginia, Whitesburg limestone.

Telephus bipunctatus, new species, Virginia, Tennessee, and Alabama, Whitesburg limestone.

Telephus impunctatus, new species, Tennessee and Alabama, Whitesburg limestone.

Telephus prattensis, new species, Tennessee and Alabama, Whitesburg limestone.

Telephus tellicoensis, new species, Knoxville, Tennessee, Tellico formation.

Telephus transversus, new species, near Knoxville, Tennessee, Tellico formation.

Telephus hircinus, new species, near Knoxville, Tennessee, Tellico formation.

Telephus bilunatus, new species, near Albany, Tennessee, Whitesburg limestone.

Telephus troedssoni Raymond, Athens, Tennessee, and Longview, Alabama, Athens shale.

Telephus buttsi, new species, near Longview, Alabama, Athens shale.

SYSTEMATIC POSITION OF TELEPHUS AND RELATED GENERA

Telephus has been variously classified by authors. Before the appearance of Hadding's work in 1913 the characters of the cephalon were not understood, so it seems unnecessary to cite views regarding the family relations of the genus prior to that date. However, in justice to Angelin it should be mentioned that for unstated reasons he classifies the genus as the type of a distinct family, Telephidae. Hadding, after a careful consideration of the relations of the genus to *Remopleurides* and *Cyclopyge*, (= *Aeglina Barrande*), the latter of which he regards the nearer to *Telephus*, concludes with the definite statement that "each of these genera must be maintained, each

genus represents a family.” More recently Raymond⁹ in proposing and defining the new family name Cyclopygidae instead of Aeglinidae Pictet—on the ground that *Aeglina*, which Barrande proposed in 1852 for his preoccupied term *Egle*, had in 1847 been given the name *Cyclopyge* by Corda—included *Telephus* as its third and last genus.

As the above heading indicates, I agree with Hadding and Angelin in viewing *Telephus* as representing a family that is quite distinct from both Remopleuridae and Cyclopygidae. Neither of those families seems to have any convincingly indicated relatives in pre-Ordovician faunas so far discovered. Still it has been rather generally assumed that the Remopleuridae are direct descendants of *Paradoxides*, and, as both are members of the Middle Atlantic fauna, I am inclined to admit their genetic relationship. However, Raymond, in the work just cited, suggests “that it is more probable that the proximate ancestor (of *Remopleurides*) is to be found in the Dikelocephalidae,” a view that receives no support from my own work on the trilobites of the latter family. Among more probable progenitors of Remopleuridae, referring particularly to such rather aberrant members as *Robergia marginata* Raymond, *Apatocephalus* should be mentioned. As to the ancestors of *Cyclopyge* and its immediate allies, I do not recall that anyone has ventured a satisfactory opinion. In my estimation they still occupy unheralded ground. *Telephus*, on the other hand, does remind rather strongly of certain Upper Cambrian and early Ozarkian trilobites. I refer, namely, to *Irvingella* and *Chariocephalus*, two genera that have given us much trouble to classify but which I now find to agree well enough with *Telephus* in their cranidia, eyes, and other details of their free cheeks, and in their pygidia to convince me of the propriety of their reference to the Telephidae. The Cambrian and Ozarkian representatives of the family originated in the Arctic realm, but so far as known they left no record in subsequent invasions of North America from that source. Probably they became extinct there but continued their development through migrants to the middle Atlantic realm which supplied the faunas that at subsequent Ordovician times invaded epicontinental basins in eastern North America and Europe.

There are two other genera of trilobites in American Upper Chazy deposits that seem to fit much better in the family Telephidae than in any other now established. One of these is *Glaphurus* Raymond, based on *Arionellus pustulatus* Walcott, 1880, from the reefy beds at the base of the Upper Chazy on Isle La Motte and elsewhere in the Champlain Valley. A close ally of this species occurs in the Whitesburg limestone in southwestern Virginia and at

⁹ Raymond, Percy E., 1925, Bull. Mus. Comp. Zoölogy, vol. 67, No. 1, p. 64.

Pratts Ferry, Alabama. The other genus, for which the name *Glaphurina* is proposed, comprises a number of closely related species to one or more of which Raymond¹⁰ applied the name *Glaphurus decipiens*. Raymond cites the occurrence of cranidia of this species, among them the holotypes from Bald Island, Mingan Islands, and adds that he "obtained a cranidium from the Lower Lenoir at Bluff City, Tenn., and another from the Holston limestone in the Catawba Valley, north of Salem, Va." If the latter two specimens are actually indistinguishable it is the only case of specific identity of Holston and Lenoir, not to say "Lower Lenoir," fossils known to me. I have two cranidia from the bed east of Bluff City that he calls "Lower Lenoir," but they are not strictly comparable with the figure of the holotype of Raymond's species. I have also a good cranidium from the Holston at Lexington, Va. But this also is not precisely like the holotype, nor is it the same as the much older Bluff City form. Finally, the collections before me comprise two cranidia of a *Glaphurina* from the reefy *Glaphurus pustulatus* bed at the base of the Upper Chazy on Isle La Motte in Lake Champlain. But these specimens also are not quite like those from the Holston and the "Lower Lenoir," nor do they agree with Raymond's figure of the Mingan Islands holotype of *G. decipiens*. Apparently there are four distinguishable varieties or species of *Glaphurina*, and it does not help us much in working out problems of stratigraphic correlation to ignore the small differences that distinguish them.

Briefly stated and as shown by figures in Plates 7 and 8,¹¹ the proposed new genus *Glaphurina*, of which *Glaphurina lamottensis*, new species, is the selected genotype, is distinguished from *Glaphurus* mainly by absence of the convex band between the anterior side of the glabella and the anterior rim. In other words, the fixed cheeks in *Glaphurus* are connected by a broad similarly pustulated band between the glabella and the anterior rim, whereas in *Glaphurina* the glabella is separated from the rim only by a narrow furrow. Except that the eyes are much smaller and the free cheeks lack the long palpebral band, the general aspect of the cranidium of *Glaphurina* is practically the same as in *Telephus*. Although known only by cranidia it seems improbable that the family relationship of *Glaphurina* and *Glaphurus* will be questioned. Assuming this without further argument, the assignment of both to the Telephidae is rendered fairly reasonable by general agreement of the pygidium, thoracic segments, and free cheeks of *Glaphurus* with *Telephus*. Figures of these parts of *G. pustulatus*

¹⁰ Mus. Comp. Zool. Bull., vol. 67, No. 1, p. 1330, pl. 8, fig. 20, 1925.

¹¹ The writer had planned to discuss these genera in a separate paper, but time to write it is not at present available.

regarded as substantiating these claims are given in Plate 8. It may be noted that even the anterior spines of *Telephus* are suggested in *Glaphurus*, and that we are again reminded of that genus by the spines on the rim of the free cheeks.

Raymond places *Glaphurus* in the Odontopleuridae (Acidaspidae), but in my opinion this genus, and particularly Raymond's *Glaphurina decipiens*, which belongs to the group of species for which I am proposing the new genus *Glaphurina*, is closer to *Telephus* and possibly also to *Cybeloides* than to any of the true Odontopleuridae. In estimating the family relations of these genera I am inclined to place as much or more weight on their pygidial characters than on those of the cephalon. The pygidia of the first two indicate close relationship, but those of the encrinurid genus *Cybelopsis* and those of the Odontopleuridae suggest very distinct families, both of which are quite apart from the Telephidae. Doubtless many kinds of trilobites with intermediate structures existed, and some of these must be discovered before anything like a clear conception of the genetic relations of the Remopleuridae, Telephidae, Encrinuridae, and Odontopleuridae may be acquired.

The descriptions of the species of *Telephus* are followed by briefer statements concerning the genotype and hitherto only known and unquestionable species of *Glaphurus*, a new species of the same genus from the southern Appalachian region, and the four species that are now known of the proposed genus *Glaphurina*. Though perhaps inadequately described this can not be said of the illustrations. These are ample and true to nature, which after all are the most desirable qualities of a paleontological contribution.

NEED OF DISCRIMINATING SPECIES CLOSELY

That some may question the wisdom of dividing the "species" as closely as it is done in following pages is suggested by the relative looseness of conception indicated by specific identifications of species of *Telephus* in European publications. If complete specimens were always available the multiplicity of characters that go to make up each particular specific combination would render its discrimination and subsequent recognition much easier and more certain than with only cranidia on which to base conclusions. After all, it is not to be expected that striking differences should occur in the cranidia of closely allied species because conspicuous modifications of its characters commonly are of higher taxonomic significance. Striking modifications that are of more strictly specific importance, such, for instance, as in surface markings, do occur in the cranidium, but as a rule most of them pertain to the free cheeks, the thoracic segments, and the pygidium. In the free cheeks

variations in the size, form, position, and direction of the genal spines and in the size and form of the eyes and in the size of their facettes, also modifications in the outline of the pygidium and in the relative proportions of its lobes and segmentation may all be immediately notable and serviceable peculiarities in comparing species whose cranidia are much less readily distinguishable. That there is abundant room for yet other easily distinguishable intermediate stages in the development of such parts appears when we compare the genal spines and eyes of *T. bicornis*, *T. mysticensis*, *T. bipunctatus*, *T. tellicoensis*, *T. mobergi*, *T. bicuspis*, and other species of which the free cheek is illustrated in this paper. That well-marked specific differences occur also in the pygidia is sufficiently indicated by comparison of these parts found with the cranidia of *T. mysticensis*, *T. fractus*, *T. bipunctatus*, *T. bicuspis*, *T. granulatus*, and other species. In short, it is highly probable and also in conformity with previous experience that if we had entire specimens even closer specific discriminations would be warranted. Moreover, experience is showing more and more clearly that if we are to get the utmost benefit from the fossils as stratigraphic and age indices it is absolutely essential to discriminate the species as closely as possible.

DESCRIPTION OF SPECIES

TELEPHUS FRACTUS Barrande

Plate 1, Figures 3-7

Telephus fractus BARRANDE, 1852, Syst. Sil. du centre Boheme, vol. 1, p. 891, pl. 18, figs. 30-34.

Trilobites expectatus BARRANDE, 1872, Suppl. vol. 1, p. 146, pl. 2, fig. 10.

Telephus fractus (Barrande) HADDING, 1913, Släktet Telephus Barrande, Meddelanden Lunds Geolog. Fältklubb, No. 18, p. 38, pl. 2, figs. 20-22.
(Discusses species and republishes copies of Barrande's figures.)

Not *Telephus fractus* of other AUTHORS.

Except Hadding's correction of previous views nothing has been added to our knowledge of this species beyond the information given by Barrande in 1852. Nor can I add anything except the statement of my conviction that as yet the species is confined to Bohemian localities. The Swedish form to which Angelin gave the name *T. wegelini* and which Tornquist subsequently referred to *T. fractus* was shown by Hadding to be distinct. Hadding also questioned Reed's identification of Barrande's species in the Whitehouse group of the Girvan District in Scotland, a doubt sufficiently warranted in my opinion to induce me to propose the new name *Telephus reedi* for the Girvan specimen. I agree with Hadding also in referring to *Telephus* the free cheek figured and described by Barrande in the supplement to his volume 1, under the name *Trilobites expectatus*,

and in believing that it belongs to this species. This cheek, judging from Barrande's figure of it, is very much like the one found in this country with *T. bicornis*.

As I have no specimens of *T. fractus* and have nothing to add to what has been published already the reader is referred to the works above cited for details not shown in the reproductions of Barrande's illustrations on Plate 1.

Occurrence.—Etage D 4, Lodewitz and Koenigshof, Bohemia.

TELEPHUS GRANULATUS Angelin

Plate 1, Figures 19–23; Plate 2, Figure 13

Telephus granulatus ANGELIN, 1854, Pal. Scand., p. 91, pl. 41, fig. 21.

Bohemilla? denticulata LINNARSSON, 1875, En egendomlig Trilobitfauna från Jemtland, G. F. F. vol. 2, p. 291. (Free cheeks.)

Aeglina denticulata (cheek) and *Telephus bicuspis* (cranidia) HOLM, 1897, Palaeont. notiser, No. 4, G. F. F. vol. 19, pp. 461 and 463.

Telephus granulatus HADDING, 1913, Släktet Telephus Barr., Meddel. Lunds Geolog. Fältklubb, No. 18, p. 35, pl. 1, figs. 8–10

Though relying mainly on Hadding's work in estimating the characters of this species comparison of his figures of Swedish specimens referred by him to the species with Angelin's figure of the Norwegian specimen on which the latter founded the species gives no convincing reason for doubt as to their specific identity. Still, and aside from certain observed differences between Angelin's and Hadding's illustrations of the cranidium that can not be explained without direct comparison of the originals, I note also—in comparing Hadding's figures 8a and 9—differences in the shape of the glabella and in the outline of the free cheek that are not readily conceivable as due to compression and which therefore suggest confusion of two closely allied species or varieties rather than individual variation. The fact that both of these cranidia possess a pair of glabellar horns is not sufficient to prove the specific identity of the animals to which they belonged. Such hornlike spines occur also in the clearly distinct American species, *T. bicornis*, the 40-plus cranidia of which afford convincing evidence of the constancy in cranial characters that prevails in species of this genus. That the word "prevails" is not too strong is indicated by similarly manifested constancy in all other American species of which numerous specimens have been found.

Occurrence.—Angelin's type of the species is said to have been found in "D a?" in Norway. The specimens referred to the species by Hadding come from the upper part of the Ogygiocaris shale in Jämtland, Sweden.

TELEPHUS BICUSPIS Angelin

Plate 2, Figures 20, 21

Telephus bicuspis ANGELIN, 1854, *Palaeontologia Scandinavica*, p. 91, pl. 41, figs. 22, 22a.

Probably not *Telephus bicuspis* of Hadding.

My conception of this Norwegian species is based entirely on the figures given of it by Angelin and herein reproduced. Hadding identifies the species in Sweden and figures a number of cranidia from there under this name. But it seems almost impossible that Angelin¹² could have so poorly represented the characters of his species as appears on comparing his dorsal and anterior views of the cranidium with the corresponding views of the Swedish specimens that Hadding refers to the species and describes and figures, evidently accurately, in his work on the genus. The validity of this doubt is further indicated by the fact that Angelin's figures of the other two of his species (*T. granulatus* and *T. wegelini*) are far less discordant with the figures given of them in Hadding's paper than in the case of *T. bicuspis*.

Under the circumstances I have decided to reproduce Angelin's original figures of *T. bicuspis* without further comment and to propose other names provisionally for the Swedish specimens that Hadding referred to this species but which it seems to me are not only distinct from it but are themselves divisible into two species. Remarks concerning these follow.

Occurrence.—Angelin's type of the species came from some locality in northern Norway, probably near Mjosen where Holtedahl lists the species as a common fossil.

TELEPHUS HADDINGI, new species (provisional)

Plate 1, Figures 11-18

Telephus bicuspis (part), HADDING, 1913, *Släktet Telephus* Barrande, *Geolog. Fören. Stockholm*, vol. 35, p. 35, pl. 1, figs. 2-7.

Apparently not *Telephus bicuspis* Angelin.

My information concerning this proposed new species is based entirely on illustrations in Hadding's work of Swedish specimens referred by him to Angelin's Norwegian species, *T. bicuspis*. As mentioned in foregoing remarks on the latter, it seems highly improbable, not to say impossible, that the Swedish specimens figured by Hadding under that name are of the same species as Angelin's *T. bicuspis*. Both Angelin's and Hadding's illustrations are photographically reproduced on Plates 1 and 2 so that the reader may form his own conclusions regarding the specific relations of the concerned specimens.

¹² *Palaeontologia Scandinavica*, pl. 41, figs. 22 and 22a.

I am further convinced that Hadding's Swedish specimens that he referred to *T. bicuspis* included cranidia of two distinct species. Three of those figured by him under that name belong to the form for which I propose the new name *T. haddingi*. The remaining fourth cranidium seems to represent a quite different species for which I propose the name *Telephus jamtlandicus*. Accordingly, I propose that the three cranidia represented by Hadding's Figures 2, 3, and 4, in Plate 1, be given the rank of cotypes of *T. haddingi*, whereas the original of Figures 1a, 1b, 1c, and 1d, in the same plate, should rank as the holotype of *T. jamtlandicus*.

Occurrence.—Lower part of the Ogygiocaris shale, Anderson, Jamtland, Sweden.

TELEPHUS JAMTLANDICUS, new species

Plate 1, Figures 8–10

Telephus bicuspis (part), HADDING, 1913, Släktet *Telephus* Barr., Geolog. Foren. Stockholm, vol. 35, p. 35, pl. 1, figs. 1a–1d, not 2–7, nor apparently *T. bicuspis* Angelin.

As mentioned previously it seems highly improbable that the cranidium represented by Figures 1a–1d, Plate 1, in Hadding's work on the genus is of the same species as the other specimens figured by him at the same time and in the same plate as *T. bicuspis*. The excepted cranidium is viewed as the holotype of the present species, the others being the basis for the proposed *T. haddingi*. The former differs from the latter in the shape of the glabella, this being wider and more bluntly truncate anteriorly and its lateral sides straighter than in the other. It differs from it also in lacking the low median ridge that is plainly indicated in both the dorsal and anterior views of all three of the cotypes of *T. haddingi*. Besides, the excavation between the two anterior denticles seems wider. In short, Hadding's figures of the two forms impress me as indicating two easily distinguishable species and leave the suggestion that *T. jamtlandicus* is really a closer relative of the Scottish *T. reedi* than of the associated *T. haddingi*.

Occurrence.—Same as the preceding.

TELEPHUS WEGELINI Angelin

Plate 2, Figures 10–12

Telephus wegelini ANGELIN, 1854, Palaeontologia Scandinavica, p. 91, pl. 41, fig. 23.

Telephus fractus TÖRNQUIST, 1884, Undersökningar öfver Siljansomradets Trilobitfauna, S. G. U., ser. C., No. 66, p. 89.

Telephus wegelini HADDING, 1913, Släktet *Telephus* Barr., p. 40, figs. 18, 19.

Angelin's figure and brief description of the cranium of this species shows and mentions—probably in error—three closely approximated anterior spines. In other respects the figure agrees well enough with the figures of two other crania given by Hadding to warrant the belief that the latter are conspecific with Angelin's type of the species. Still it should be pointed out that the figures of the two crania used by Hadding show certain differences that are not all readily accounted for as due to distortion in the compression of the shale matrix. The relative shortness and the greater anterior width and bluntness of the glabella in Figure 19 as compared with Figure 18 is readily explained on that ground, as is also the difference in the relative sharpness of the antero-lateral angles. But I do not see why the anterior spines should be so much farther apart in Figure 19 than in Figure 18 if the same structures are shown in both. In fact I strongly incline to the belief that it is the inner pair that is shown in Figure 18 and only the outer pair in Figure 19.

Assuming that Hadding's Figure 18 represents something near the normal outline of the species it suggests *T. spiniferus* perhaps more than any of the other American species. In both the occipital spine is long and the surface tuberculated. However, the tubercles are smaller and more numerous in the Swedish species, and the figures give no indication of their longitudinal arrangement on the middle of the glabella nor of those on the fixed cheeks that are so strikingly indicated on the head of the American species. Besides, the free cheeks are narrower behind and wider in the middle in the latter and their outlines more rounded than in *T. wegelini*.

Occurrence.—Trinucleus shale, at localities in Dalarne, Sweden.

TELEPHUS MOBERGI Hadding

Plate 2, Figures 1-9

Telephus mobergi HADDING, 1913, Släktet Telephus Barr., Medd. Lunds Geolog. Faltklubb, No. 18, p. 37, pl. 2, figs. 12-17.

This doubtless is a good species and clearly distinguishable from previously described European species. It is also of unusual interest to me because its kinship to two or three of our American species is more obviously indicated than in any of the other instances. In one case, indeed, I am not sure that *T. troedssoni* Raymond, to which I am referring also some distorted American specimens from Alabama, can be distinguished satisfactorily from this Swedish species. The second American ally, of which many excellently preserved crania have been found and which seemed at first referable to *T. mobergi*, has proved on detailed comparison to differ too much in various respects from Hadding's illustrations of his species to permit using the same name for both. These differences are pointed out in re-

marks included in the description of *T. bipunctatus*, which is the name given to this second American relative of *T. mobergi*. The Swedish species is referred to also in the descriptions of *T. prattensis* and *T. transversus*, both of which, though more obviously different, I believe to be as near if not even closer allies of *T. mobergi* than is *T. bipunctatus*.

If Hadding's description of *T. mobergi* were in English it would be quoted here. But my acquaintance with the Swedish language is too limited to warrant an attempt to translate it, so the illustrations which are photographically reproduced here must suffice for the present.

Occurrence.—Lowest beds, (*Climacograptus putillus* zone), of the Ogygiocaris shale, Andersön, Jämtland, Sweden.

TELEPHUS LINNARSSONI, new species

Plate 2, Figures 15–17

Telephus wegelini ANGELIN, Warburg, 1925, Trilobites of the Leptaena limestone in Dalarne, p. 90, pl. 1, figs. 16–18.

This name is proposed for an imperfect cranidium supposedly collected by Linnarsson from the Leptaena limestone in Dalarne, Sweden, and which, according to Warburg, he evidently regarded as a new species and labeled *Telephus superstis*. Warburg,¹³ however, was unwilling to accept Linnarsson's opinion, being persuaded that the observed differences between the Leptaena limestone specimen and those found in the underlying Black Trinucleus shale that are identified by Hadding and other authors with Angelin's *T. wegelini* are due mainly to distorting compression of the latter. To what extent Warburg's view of the systematic relations of the concerned specimens is warranted I am, of course, not prepared to say. But, assuming that the illustrations given by Hadding of typical *T. wegelini* and those of the Leptaena limestone specimen by Warburg are essentially correct, comparison of these brings out certain differences that after considerable experience in evaluating the effects of distortion of fossils by either vertical or lateral compression of the matrix seem to me unlikely to have been produced by such causes. For instance, the relative straightness of the anterior part of the outline, the protrusion of the two median denticles, the straightness of the posteriorly converging palpebral bands, and the truncate-conical rather than truncate-ovate outline of the glabella—all as seen in dorsal views of the cranidium of typical *T. wegelini*—could hardly have been produced by vertical compression of specimens precisely like that of the Leptaena limestone illustrated by Warburg. In the

¹³ Trilobites of the Leptaena limestone in Dalarne, 1925, p. 90.

latter the anterior denticles are directed vertically downward, hence they do not show in a dorsal view; nor could they except the cranium were so obliquely imbedded with respect to the bedding plane of the matrix that in the compression of the latter the length of cranium—particularly the distance between the anterior margin of the glabella and the posterior edge of the occipital ring—would be greatly reduced. Nothing like this is indicated by comparison of the figures. On the contrary, the median thickness or width of the occipital ring in Warburg's figures of the *Leptaena* limestone specimen instead of being less, as it should be, than in Hadding's figures of supposedly typical specimens of *T. wegelini* is distinctly greater.

In view of these probable facts I am convinced that the *Leptaena* limestone specimen in question is not conspecific with *T. wegelini* and therefore propose to distinguish and name it as above in honor of the keen collector and observer who preceded me in recognizing its specific entity.

As I see it, the species that is as near as any to *T. linnarssoni* is the Bohemian genotype *T. fractus* Barrande. Warburg recognizes this relation but regards them as distinct. However, in pointing out the features in which they differ, that author mentions one that indicates comparison of typical *T. wegelini* with *T. fractus* rather than *T. linnarssoni*. In the latter the front and sides of the glabella are convexly curved throughout so that the sides even converge for a considerable distance posteriorly. In fact posterior rounding of the outline of the glabella is so unusual in species of the genus that it struck me at once; and it is particularly notable in comparing Warburg's figure of this cranium with Hadding's figures of *T. wegelini*.

Warburg¹⁴ having published a detailed description of the holotype of *T. linnarssoni* under the name *T. wegelini* in English it seems better to quote this than to attempt a description of my own:

Cranidium about two thirds as long as wide. Axial furrows outside occipital ring very shallow, outside glabella deep and gently arched upwards, at first slightly, but gradually getting more strongly convergent; at the anterior margin of glabella they bend nearly straight inwards and somewhat downwards, and are united by the short, nearly straight, and considerable narrower preglabellar furrow. Glabella slightly more wide than long, oval, truncated at base, rather swollen, highest joint in front of occipital furrow, posteriorly slightly keeled, front part somewhat overhanging. On the sides of the glabella rather far forwards, there is a pair of very shallow, hardly discernible impressions recalling the more distinct impressions in some other species of this genus, as for example, *T. Mobergi* Hadding,¹⁵ and *T. americanus* Billings.¹⁶ Another slight impression is seen near the base of the glabella on one side,

¹⁴ Trilobites of the *Leptaena* limestone in Dalarne, 1925, p. 90.

¹⁵ 1913, *Släktet Telephus* Barr, Geolog. Fören. Stockholm, vol. 35, p. 37.

¹⁶ Hadding, *idem*, 1913, p. 37, pl. 2, figs. 12-17.

on the other the test is not preserved at the corresponding place. Probably these impressions represent the glabellar furrows. Occipital furrow shallow, rather broad, not reaching axial furrows, its middle part slightly arched forwards, its lateral parts backwards. Occipital ring broad in the middle (from back to front), tapering towards the sides; convexity of anterior edge about the same as of posterior part of glabella, postero-lateral portions more strongly bent down and flattened, antero-lateral portions gently rounded; different portions separated by fine furrow, which disappears at base of median spine, which latter is broken off in this specimen. Glabella and occipital ring ornamented with sparse tubercles and net of very fine ridges, except at impressed places on glabella, in the anterior pair of which are a few rounded pits irregularly distributed. Doublure of occipital ring with fine transverse striae.

Fixed cheeks gently bent down, rather narrow, widest just behind front of glabella, gradually decreasing in width posteriorly to posterior margin; this continues far outside part in front, is rather strongly bent down and obliquely cut off by posterior branch of facial suture, which here takes a sharp turn outwards. Anterior margin of cheek directed somewhat backwards; antero-lateral angle rounded. Inner part of cheek rather flat in the middle, sloping down toward the margin. Inner anterior portion with net of ridges coarser than on glabella, a more strongly raised ridge along lateral and posterior margins. Palpebral lobe set off by clearly marked furrow, extending round anterior and lateral margins of inner part of cheek, flattened, slightly bent down at antero-lateral angle, rather broad in front, gradually tapering posteriorly. Anteriorly it continues underneath overhanging anterior portion of glabella along foremost part of dorsal furrow. Where this furrow meets preglabellar furrow (which here is the same as the anterior border furrow of cephalon, since there is no preglabellar field), the palpebral lobe bends steeply downwards, forming together with lateral part of narrow, more swollen, and strongly arched anterior border, the small anterior spines characteristic for this genus.

None of the American species is very closely allied to this youngest, apparently early Silurian, species. It suggests a cross between the *T. bipunctatus* and *T. fractus* groups, the general shape of the glabella and the obscure depressions on its lateral slopes reminding of the former, whereas the slight anterior overhang of the glabella and the abrupt downward direction of the median denticles are more in accord with the latter.

Occurrence.—Leptaena limestone, Boda, Dalarne, Sweden. Holotype in the Museum of the Geological Survey of Sweden.

TELEPHUS HIBERNICUS Reed

Plate 2, Figures 18, 19

Telephus hibernicus REED, 1909, Quart. Journ. Geol. Soc. London, vol. 65, p. 149, pl. 6, figs. 10 and 11.

Original description.—

Several small detached head-shields of a trilobite, with the peculiar characters of *Telephus*, occur in the crystalline reddish limestone (58) exposed west of Gortbunacullin Farm bridge. None are very well preserved; but, by piecing

together the evidence from the different specimens, the following description can be given.

Head-shield transverse, more than twice as wide as long. Glabella broadly semioval to subquadrate, nearly as wide as long, narrowing a little anteriorly, strongly convex, rounded in front. Occipital furrow slightly arched forward in the middle or straight; occipital segment simple. Axial furrows sharp, moderately strong, slightly convergent anteriorly. Cheeks much lower and less convex than the glabella, almost horizontally extended or slightly arched down on each side, of rounded or subtriangular shape, nearly as broad as long, surrounded by a flattened border, which broadens gradually to the middle, then decreases in width until it merges into the narrow anterior border in front of the glabella. Marginal furrow sharp, but not deeply impressed. Glabella and cheeks minutely tuberculated.

Dimensions.—Length=about 3 millimeters; width=about 6.5 millimeters.

Remarks.—This species seems almost indistinguishable from *T. bicuspis*, Angelin, but no pair of anterior spines has been observed in any of our specimens. The shape of the glabella, relatively wider cheeks, and absence of a median occipital spine distinguish it from *T. fractus*, Barr., which I have described [see *T. reedi*, n. sp., p. 19] from the Whitehouse Group in the Girvan district.

Judging from the quoted description and figures reproduced here in Plate 2, this species differs from all other Telephidae now known in the relative narrowness and parallel-sidedness of the glabella and the great median width of the fixed cheeks and nearly symmetrical curvature of their outer edges. The slight differences in these respects shown in Reed's figures of two cranidia may be accounted for by assuming that the original of his Figure 10 (reproduced here as fig. 18 in pl. 2) suffered some distortion by longitudinal compression, causing shortening of the glabella and cheeks and obtuse median angulation of the outline of the latter. Accordingly, I am inclined to regard his Figure 11 as probably a closer approximation to the undistorted original form of the cranidium. Reed probably is right in suggesting that his species is a close relative of the Norwegian *T. bicuspis* Angelin. However, this probable relationship is indicated much better by comparison with Angelin's figures of his species than with the figures of Swedish specimens referred to *T. bicuspis* by Hadding. The probability that Hadding misidentified Angelin's species is discussed on page 12.

Reed says that the anterior spines were not observed in his specimens. Most probably they are directed sharply downward as they are figured by Angelin in his *T. bicuspis* and as they do in *T. gelatinosus* and other American species of the typical section of the genus. In most of these cases delicate preparation of the specimens is required to reveal their presence, for even their bases are seldom shown in natural fracturing of the matrix.

Occurrence.—Tourmakeady Beds, near Tourmakeady, County Mayo, Ireland. According to a report on this district by Gardiner,

Reynolds, and Reed,¹⁷ the Tourmakeady Beds are of Llandeilo age, which, however, is not very definite as regards the American sequence. Judging from the general aspect of the fauna listed from these beds, I am inclined to place them about the Middle or Upper Chazyan.

TELEPHUS REEDI, new species

Plate 1, Figure 1

Telephus fractus BARRANDE, Reed, 1903, Lower Paleozoic trilobites of the Girvan District, Paleontogr. Soc., p. 44, pl. 4, fig. 11.

This new name is proposed for the Girvan species of which incomplete cranidia were mentioned and one figured by Reed in 1903 and all referred by him to the Bohemian species *T. fractus* Barrende. Although the figured specimen is very imperfect and I have nothing better to base an opinion on than the figure given of it by the mentioned author, it yet seems impossible that it can be strictly the same species as *T. fractus*. Nor does it seem likely that it belongs to any of the Scandanavian species or to any of the American species herein described. Assuming that the figure is reasonably true to nature it must represent a species with an anteriorly extraordinarily truncated, subquadrate glabella that distinguishes it at once not only from *T. fractus* but also from all other species of the genus now known. Perhaps the nearest of the American species is my *T. spiniferus*, but comparison of the illustrations of the two forms on following plates can hardly fail to convince the observer that they are not even closely allied.

Compared with European species I note considerable resemblance to the similarly incomplete cranidium referred to *T. bicuspis* by Hadding and illustrated by Figures 1a and 1b in Plate 1 of his work on the genus. As figured the anterior end of the glabella of this specimen, which is provisionally distinguished on page 13 as *T. jamtlandicus*, is blunter—more truncate—and its lateral sides straighter than in the three other cranidia used by Hadding in illustrating the characters of this Swedish species. Nor does either the dorsal or the anterior view of it give any suggestion of the low ridge that is plainly indicated on the other figures as running longitudinally across the middle of the glabella. In all these respects this specimen makes a closer approximation to conditions found in the glabella of the holotype of *T. reedi*. Though it is believed that Hadding confused and included two distinguishable forms in the Swedish material referred by him to *T. bicuspis*, it seems certain that neither of them is strictly conspecific with the type of this Girvan species. The free cheeks in the latter are relatively too small and the curvature of their outer margins too sharp to justify identification in either case.

¹⁷ Quart. Journ. Geol. Soc. London, vol. 65, pp. 104-154, 1909.

It is possible that the anterior truncation and overhang of the glabella of the Girvan type of this proposed new species was emphasized by pressure and oblique position of the cranidium with respect to the bedding plane of the matrix. But if this explanation of its present extraordinary appearance is correct it would at the same time imply uncommon original length of glabella. Under the circumstance I feel warranted, at least provisionally, in proposing the above new name for this Girvan species.

Occurrence.—Whitehouse group, Whitehouse Bay, Girvan District, Scotland.

TELEPHUS? SALTERI Reed

Plate 2, Figure 14.

Telephus salteri REED, 1914, Supplement Lower Paleozoic trilobites of Girvan, Paleontog. Soc., p. 16, pl. 2, fig. 11.

Original description.—

Specific Characters.—Head transversely elliptical. Glabella sub-cylindrical, slightly expanded at front end and projecting a little beyond cheeks, abruptly truncate, moderately convex, more than twice as long as wide at base; surface coarsely tuberculated. Axial furrows parallel for three-fourths length of glabella, diverging slightly at front end. Meso-occipital furrow distinct, marking off rounded smooth depressed meso-occipital ring, widest in middle. Cheeks rounded, nearly semi-elliptical, widest behind middle, rather wider than glabella, gently convex, with rather broad smooth flattened border extending round them and ending against glabella in front and at meso-occipital ring behind; marginal furrow strong; surface of cheeks granulated and with a few coarse tubercles on outer half.

Dimensions.—

Length of head-shield.....	3.6 mm.
Length of glabella.....	2.8 mm.
Width of head near base.....	5.4 mm.
Width of glabella at base.....	1.5 mm.
Width of cheek, (maximum).....	2.1 mm.

Remarks.—There is only one specimen of this curious little trilobite available, but with the exception of the front end of the glabella it is well preserved. It is uncertain if a pair of anterior spines is present as in *T. bicuspis*, Ang., which it much resembles, though the cheeks in ours are relatively broader and more semi-elliptical and the glabella more cylindrical, and the neck-ring smooth and projecting behind the cheeks.

Judging from the description and figure of the holotype of this species it stands well apart from all others now known. Indeed, and particularly in view of the general sameness of the 20 or more other species of the genus, I doubt very much that its reference to *Telephus* is quite justifiable. The others in no case suggest that normal specific modification of the generic characters could produce the unheralded structural peculiarities of *T. salteri*. Among the more striking of these is the relative narrowness of the glabella and, especially, its anterior expansion. Equally unexpected is the shape of the fixed

cheeks and the fact that the edge of the outer band, which should correspond to the palpebral band, departs farthest from the dorsal furrow at the posterior lateral angles of the cranium instead of in front. The anterior extension of the middle part of the head also is difficult to understand as a normal modification of the generic type. To say the least we require more information concerning this trilobite before it can be accepted as a properly classified and unquestionable species of *Telephus*.

Occurrence.—Balclatchie group, Balclatchie, Girvan District, Scotland.

TELEPHUS AMERICANUS Billings

Plate 2, Figures 22-27

Telephus americanus BILLINGS, 1865, Pal. Foss. 1, Geol. Survey Canada, p. 291, fig. 281.

Telephus americanus HADDING, 1913, Släktet *Telephus* Barr., Geol. Fören. Förhandl., vol. 35, Häft 1, p. 4, text fig. 1a, b.

Original description.—

Glabella obtusely conical, length one-sixth greater than the width, rather strongly convex; front uniformly rounded; sides parallel; neck segment and furrow forming nearly one-third of the whole length; the furrow narrow and extending all across. The fixed cheeks are crescentiform, rounded on the outside, terminating posteriorly at the front edge of the neck furrow and extending around one-third of the width of the front of the glabella; an obscure groove just outside of the middle of the cheek, parallel with the margin in the front half, but running out to the edge before reaching the posterior corner. In front of the glabella there are two small projecting points. The surface is obscurely tubercular, and there is a small tubercle on the middle of the neck segment.

Length from two to three lines.

The detached glabellæ occur in considerable numbers, but I have seen none of the other parts in connection with any of them. There are no fragments that can be identified as belonging to this trilobite, except the glabella.

Through the kindness of Dr. E. M. Kindle, of the Geological Survey of Canada, I was given the opportunity of studying five cranidia used by Billings in describing this species. These were photographed, and plaster casts made of them are now in the United States National Museum. Three of the cranidia doubtless are strictly conspecific, the fourth also may be but requires more preparation before it will be fit for final classification. The fifth, which has a longer glabella, with straighter sides, a pair of faintly impressed pits, and smoother surface, may belong to a distinguishable variety or species. As these specimens show slight differences I propose that the one which bears the number 700b be selected as the holotype of the species. It is the best of the lot and most probably is the one figured by Billings and also the one of which the plaster cast was

made and mainly relied on by Hadding in preparing the drawings published by him.

The mainly distinctive features of the cranidium of *T. americanus* are the rather strong convexity and semioval outline of the glabella, the small size and weak development of its surface tuberculation, the small anterior width and crescentic form of the fixed cheeks and the resulting general roundness of the lateral and anterior parts of the outline, and the relative narrowness of the occipital ring and the reduction of its spine to a minute elongate medially located node. Its nearest ally seems to be *T. mysticensis*, which, however, lacks the surface tuberculation, has somewhat wider and more crescent-shaped occipital ring, less evenly convex glabella, less sharply ridged fixed cheeks, and apparently more delicate anterior denticles. The nearest of the southern Appalachian species is *T. prattensis*, but the wavy and anastomosing longitudinal lines on its glabella and fixed cheeks, instead of pustules, render confusion in this case unlikely.

Occurrence.—Newfoundland, Division N and P, which probably locates the species stratigraphically somewhere within the span covered in the southern Appalachian region by the Blount group.

TELEPHUS MYSTICENSIS, new species and SIMULATOR, new variety

Plate 6, Figures 1-7

The surface of the glabella and fixed cheeks in both the typical form of the species and its variety seems entirely without tubercles, and if the occipital ring has a median tubercle or spine it must be very small. The shape and contour of the glabella is essentially as in *T. fractus* and *T. americanus* except that its middle third is flanked on each side by a shallow curved depression and the occipital ring is wider in the middle and more crescentic in outline. The outline of the sides and front of the cranidium in the holotype is rounded about as in *T. americanus*, but the part that lies in front of the middle third of the glabella is more prominent and distinctly incurved in front and the inner pair of the four frontal spines relatively small and so strongly curved downward that only the bases of these spines are visible in a dorsal view. The outer pair, however, is distinctly visible in such views. The fixed cheeks are as narrow as in *T. americanus*, but the convex area is longer, extending forward as a diminishing low ridge almost as far as the anterior extremity of the glabella. Excepting *T. americanus* the present species differs from all the other species of the genus in the approximately semicircular outline of its cranidium, in the general narrowness of its fixed cheeks, and in the fact that the convex areas of these cheeks are widest posteriorly instead of anteriorly and the outer pair

of the four anterior spines appear larger than the inner pair in dorsal view.

Comparisons with *T. granulatus* Angelin, founded on Swedish specimens, are given in preceding remarks on that species.

The larger of the two cranidia of this species now available, namely the one regarded as the holotype, shows some obscurely defined shallow depressions on the lateral slopes of the glabella. These suggest imperfectly developed glabellar furrows or dimples as occur in *T. bipunctatus* and *T. mobergi*. The second cranidium lacks these depressions and differs further from the holotype of the species in the more conical form of its glabella and in the greater width of the fixed cheeks. As it approaches *T. prattensis* in these respects it is provisionally distinguished as var. *simulator*.

Strangely, the preparation of our collections from Mystic revealed more than 10 free cheeks but only 2 cranidia and 2 pygidia. These cheeks are readily distinguishable from all others so far observed. The eyes, as usual, constitute by far the greater part of the cheek, but they are uncommonly bulbous and very finely faceted. Another peculiarity is that the thin rim carries no spine, only widening and the outline becoming obtusely angular at a point slightly behind the middle of the compound eye. Slight differences were noted in comparing these cheeks. In one set (figs. 3, 4), supposed to belong to the typical form of the species the eye is slightly longer, the rim wider and more sharply curved at the genal angle, and the anterior edge of the eye more distinctly overhangs the very thin anterior rim of the cheek than in the other set which is supposed to belong to the variety.

Two pygidia referred to this species agree in segmentation and general character fairly well with the pygidium ascribed to *T. fractus* by Barrande. However, they are longer and more quadrate or rather pentagonal than triangular and terminate posteriorly in a sharp angle or short spine and show a pair of still blunter projections at points nearly midway between the median posterior spine and the antero-lateral angles.

Occurrence.—From a highly fossiliferous limestone boulder supposed to be of Blount, or at least Chazyon, age in the conglomerate near Mystic, in the southwestern corner of the Province of Quebec.

Holotypes of species and variety.—Cat. Nos. 80526, 80527, U.S.N.M.

TELEPHUS BICORNIS, new species

Plate 4, Figures 1-14

As shown by the illustrations the cranidium of this species agrees rather closely in all save one conspicuous feature with the cranidia of *T. pustulatus*, *T. gelasinosus*, and one or two others of the numerous American species here described. The distinctive character re-

ferred to and which suggested the species name *bicornis* is the presence of a pair of long and rather slender spines or horns at the top or beginning of the frontal slope of the glabella. These spines project obliquely forward, outward, and upward and have a length approximately equaling half the width of the glabella. The surface is pustulated and the occipital spine well developed as in the mentioned species. The fixed cheeks differ slightly from those of *T. pustulatus* in their outlines and more particularly in being decidedly narrower. The eyes, as usual, are very large and, disregarding the genal spines, make up much the greater part of the free cheeks. The height or width of the visual surface is to its length about as one to three. In the middle third of the eye of an adult specimen about 23 facets occur in each of the diagonally intersecting rows. The outer rim of the cheek is narrow and prolonged at its widest point into a long, straight, compressed, and obliquely striated genal spine. The base of the latter lies somewhat behind the middle of the eye, projects almost directly outward and attains a length slightly exceeding that of the eye. The pygidium is obtusely triangular in outline, its axis wide and high, clearly outlined, and crossed by three double rings, each of which carries a pair of strong spinelike knots in its middle third, some small tubercles outside of these, and a low swelling at each end. The pleural lobes are narrow, the outer half broadly concave, the inner half rising into a low ridge on which two segments are obscurely indicated.

Whereas the striking glabellar spines serve very satisfactorily in distinguishing *T. bicornis* from all the other American species of the genus and also from all but one of the European species, their value as a distinguishing character fails when we compare it with the similarly bicornute Swedish species to which Angelin applied the name *Telephus granulatus*, especially as that species is illustrated by Hadding. Indeed, when I first saw the latter's figures of *T. granulatus* I welcomed them as probably giving the first valid grounds for the identification of an American species of *Telephus* with an European one. This relation was suggested particularly by the smaller cranidium shown in his Plate 1, Figure 9, which differs from the larger, apparently more typical, example of the species shown in Figures 8a, b, c, in the straighter anterior outline of the cranidium and the more conical and anteriorly more narrowly rounded glabella. In both respects this smaller cranidium makes a closer approach to the cranidium of *T. bicornis* than does the larger specimen. Possibly the noted differences are due to distortion by rock compression or to differences in posing. Whatever the reason may be, whether structural or fortuitous, careful comparison with the published figures of the Scandinavian species, including the one given by Angelin, leaves no doubt as to the distinctness of the American bicornute

species. Some 40 cranidia of the latter, while indicating extraordinary agreement among themselves, differ constantly from the figures of Norwegian and Swedish specimens referred to the former in (1) the greater width, contour, and shape of the fixed cheek; (2) in the inferior length, more regularly semielliptical outline, and greater median convexity of the glabella; (3) in the greater separation and less anterior position of the bases of the glabellar spines; and (4) the presence of tubercles on the outer parts of the fixed cheeks and the wider distribution of the tubercles on the glabella and also on the occipital ring. Other less conspicuous differences will be observed in comparing figures of the two species; the occipital spine, for instance, seems to be stronger, whereas the ridge on the free cheeks is not so sharp as indicated in Hadding's illustrations.

Comparison of their respective pygidia discloses equally distinctive peculiarities. Hadding's illustration of this plate in *T. granulatus* shows two axial rings behind the anterior half ring, each of the two with a single median tubercle or short spine and without other tubercles. In *T. bicornis*, on the other hand, a narrow tuberculated third ring makes the posterior extremity of the axis, and each of the two rings in front of it carries a pair of spines and besides these one or two rows of tubercles between them and the dorsal furrows.

The free cheeks, except for the large bulbous and beautifully faceted eyes, are very narrow. Except at the genal angle only a narrow smooth rim follows the outline of the eye. The genal spine begins with a broadly swollen and outwardly rapidly tapering base, its further extension being very long and slender, only slightly curved, and obliquely striated. A much shorter spine lies just behind it.

Only two thoracic segments were found, and both consisted only of the axial part. Though similarly covered with tubercles, one carried the expected pair of median spines, but the other (see pl. 4, fig. 14) had only one and this in the middle of the axis. The pleural parts are short and apparently terminate bluntly.

Because of the two glabellar horns it is not likely that reasonably complete cranidia of this species will be confused with any of the other species here described. A like statement regarding the free cheeks and pygidia would scarcely be warranted because we know these parts of only a few of the species. But they are surely quite distinct from the few other kinds of *Telephus* free cheeks and pygidia that have been discovered. That those referred to *T. bicornis* actually belong to this species is rendered fairly certain by the fact that whereas cranidia were abundant in a thin layer at the type locality no other species of the genus was found either with them or in any other bed at this place.

Occurrence.—Whitesburg limestone, John Grayson's farm, about 4 miles southwest of Bland, Va.

Cotypes.—Cat. No. 80535, U.S.N.M.

TELEPHUS GELASINOSUS Ulrich

Plate 7, Figures 12-14

Telephus gelasinosa (Ulrich) BUTTS, 1926, *Geology of Alabama*, pl. 19, figs. 1, 2.

This species is characterized by the combination of a relatively long glabella, rather narrow strongly convex free cheeks, somewhat rounded anterior outline, pustulose surface, and strong, sharply deflected anterior spines. The glabella is strongly convex along its middle with distinctly flattened lateral slopes, truncated conical, the maximum length and width about equal. The posterior lobes are outlined by a small inwardly diminishing ridge instead of a furrow. Unfortunately both specimens on which the species is founded lack the posterior edge of the occipital ring, so it is impossible to say anything concerning the character of the occipital spine that probably occurs on more perfect specimens.

Compared with other American species of the genus, *T. gelasinus* is at once distinguished by its relatively longer glabella. It is approached in this respect, also in the size, outline and contour of the fixed cheeks, by *T. granulatus* Angelin but differs conspicuously in the shape of the glabella, which is distinctly conical instead of subquadrate. It lacks also the two horns on the anterior slope of the glabella that set *T. granulatus* and *T. bicornis* apart from all the other species of the genus. The present species reminds also of *T. latus* but has a longer and more convex glabella, more sharply deflected anterior spines, and, particularly, narrower and more strongly convex fixed cheeks. In the two remaining pustulose species, namely, *T. pustulatus* and *T. fractus* Barrande, the glabella is much shorter and semioval rather than conical.

Occurrence.—From a subgranular limestone containing *T. bipunctatus* in abundance, at Pratts Ferry, Ala. This bed of limestone lies between the base of the graptolite-bearing Athens shale and the top of the Lenoir limestone, hence its position corroborates the evidence of its fossils on which mainly it is correlated with the Whitesburg limestone of Tennessee and Virginia.

TELEPHUS LATUS, new species

Plate 3, Figures 13, 14

This species is based on two cranidia. These agree in size with *T. fractus*, the Bohemian genotype, but are considerably larger

than any of the other American species. The outstanding structural characteristic lies in the form and size of the fixed cheeks. The outline of these is more regularly curved and their convex areas broader and more flatly convex than in any other species of the genus. On the other hand, the outer pair of the frontal spines is uncommonly weak, being reduced, as in *T. fractus*, to mere angulations of the thickened rim. The occipital ring is only moderately wide and the neck spine exceedingly short and directed backward. Just in front of the latter is a distinct rounded node that may represent the "median eye" of *Isotelus* and many other trilobites. A minute body similar to that described by Ruedemann as the lens of this probable eye was observed in preparing the specimens.

The convexity of the glabella is less than in specimens of most of the other species of the genus, but this inferiority is regarded as due in small part to reduction in rock mass by pressure subsequent to fossilization. As in *T. fractus* and other species the convexity of the glabella is greatest in the middle, the convexity of the lateral slopes being appreciably lessened so as to produce an obscurely defined median ridge. The entire surface of the glabella is loosely covered with low tubercles that seem to be more plainly indicated on the cast of the interior than on the outer surface of the test. Similarly arranged but even lower pustules occur on the anterior half of the gently convex areas of the fixed cheeks. A low ridge crowned with a row of tubercles defines the outer limits of the convex areas and assists in deepening the palpebral furrow.

In general aspect *T. latus* reminds considerably of Angelin's *T. granulatus* but is clearly distinct, attaining nearly twice the size of that species and having a more conical glabella and wider as well as less convex fixed cheeks. It also lacks the two large nodes or spines on the anterior slope of the glabella and has a shorter occipital spine.

Occurrence.—This species has been found only in the limy basal part of the Athens shale at the north end of the old limestone quarry, nearly 3 miles southeast of Saltville, Va. Here it is associated with *Telephus spiniferus*, *Robergia major* Raymond, *Ampyxina powelli* Raymond, and various species of graptolites, including *Nemagraptus gracilis* Hall. Although seemingly occupying the position of the Whitesburg limestone, the fauna consists practically entirely of Athens shale species and not of Whitesburg limestone fossils. Evidently the zone of *Robergia major* belongs to the Athens and not in the older Whitesburg formation.

Holotype.—Cat. No. 80539, U.S.N.M.

TELEPHUS PUSTULATUS, new species

Plate 3, Figures 1-10

The cranium of this species reminds in many respects of *T. latus*, having like it a very short spine projecting from the middle of the posterior edge of the rather narrow occipital ring and in front of this a conical elevation, wide and only moderately convex fixed cheeks and similarly placed pustules on the glabella, occipital ring and fixed cheeks. However, *T. pustulatus* differs from the Saltville species in the greater convexity of the glabella and fixed cheeks, more strongly developed surface pustules, and in the shape and dimensions of the glabella, this being shorter, less conical in lateral outline, and more rounded in anterior outline than in *T. latus*. Further, the greatest width of the cranium is proportionately greater by a third mainly because of the relative shortness of the glabella. Finally, all the furrows are deeper, the outline of the fixed cheek is less regularly rounded, making the anterior outline of the cranium straighter and the anterior spines turn downward more rapidly than in the larger species.

As usual the free cheek consists mainly of the great eye. This is sharply separated by a deep groove from the narrow outer rim. The latter widens slowly backward to attain its greatest width at the base of the genal spine. The latter, contrary to expectations, does not extend outwards but rises erect from the top surface of the rim and in such manner that its lower part is in contact with the faceted part of the eye.

The pygidium consists mainly of the axis, the pleural lobes being narrow and comprising little else than a concave border. The axis is rather broadly triangular, has three, or it may be only two, rings, the first and especially the second being rather wide and flat-topped and separated by deep grooves, the third much smaller and thinner and close to and probably merging with the posterior rim of the pygidium. Each of the rings carries a low node on its postlateral angles, the second shows the broken base of an antero-median spine whereas the first shows the base of a more centrally located spine with three or four small tubercles on each side of it. The dorsal furrows are shallow, and outside of them the convex parts of the pleural lobes make very narrow low ridges that merge with the sides of the second axial ring.

Compared with European species only *T. fractus* Barrande appears on first sight much like *T. pustulatus*. However, this resemblance rests mainly on the similarity in their respective glabellas, detailed comparison showing more or less clearly recognizable difference in all other parts.

Occurrence.—The types were found in the Whitesburg limestone at Lexington, Va. With them occurred a specimen agreeing in all respects except the glabella, which is a trifle longer. Another cranidium was found in the same formation near Albany, Tenn. The latter being somewhat distorted by pressure I could not decide whether its structure is more like that of the types of the species or like the second variety.

Holotypes and paratypes.—Cat. No. 80536, U.S.N.M.

TELEPHUS SPINIFERUS, new species

Plate 3, Figure 11

The holotype of this species—a rather well-preserved cranidium—has only about half the width from palpebral edge to palpebral edge as do the specimens of *T. latus* with which it was found. It differs also very decidedly when details of structure are compared. In the first place, whereas *T. latus* has a very short occipital spine the corresponding spine on *T. spiniferus* is stronger and much longer, its length being nearly equal to that of the glabella in front of the occipital furrow. Next, the fixed cheeks are wider in front and extend forward beyond the anterior extremity of the glabella. In consequence the anterior outline of the cranidium is different, being slightly but definitely concave in its inner three-fifths and the whole anterior and lateral parts of the outline much less convexly bowed. The antero-lateral outline of the convex areas of the fixed cheeks and also of the palpebral bands is more sharply curved. Third, the convexity of the whole and particularly of the glabella is relatively less in *T. spiniferus* even when the slight vertical compression of the specimens is taken into account. Finally, the tubercles of the surface of the glabella and over the anterior half or more of the convex areas of the fixed cheeks though smaller are more distinct and more numerous, and those on the middle half of the glabella exhibit a more regular arrangement in anteriorly slightly diverging rows.

The unusual length of the occipital spine and the longitudinal arrangement of the surface tubercles on the middle of the glabella will distinguish this species at once from most if not all others of the genus. A long spine occurs also in one of the varieties of *T. bipunctatus* and in other species—notably in *T. troedssoni* and *T. buttsi*—but in all these cases the differences in other respects are too conspicuous to be likely to cause confusion.

Occurrence.—The holotype was found in association with *Telephus latus*, *Robergia major* Raymond, and graptolites of several species in the limy basal part of the Athens shale overlying Holston limestone in the large quarry 3 miles southeast of Saltville, Va.

Holotype.—Cat. No. 80537, U. S. N. M.

TELEPHUS SPINIFEROUS CALHOUNENSIS, new variety

Plate 3, Figure 12

This name is proposed provisionally for a single cranidium that has lost its posterior part but retains its anterior and middle parts in reasonably good condition. What remains of it recalls *T. spiniferus* rather more than any of the other species known to me. On this account and pending discovery of information respecting the specifically important occipital ring and spine present purposes are sufficiently served by classifying it as a variety of this species. At least two peculiarities warrant its separation from typical *T. spiniferus* and even suggest that a complete head would demonstrate quite as close relations to such other species as *T. mobergi*, *T. Sinuatus*, and *T. bilunatus*. In fact, I am satisfied that when such specimens are discovered they will give ample grounds for the promotion of the variety to the rank of a distinct species. At present, however, we are mainly concerned with the features that distinguish it from typical *T. spiniferus*. The first of these, as the reader will observe in comparing their dorsal views in Plate 3, lies in the outline of the gabella, which diverges more rapidly backward, then curves inward before reaching the occipital furrow and gives a greater width to the posterior fourth of the glabella in the variety than in the older typical form of the species. The second difference pertains to the presence of shallow curved furrows in the posterior two-thirds of the glabella in the variety and their absence in the holotype of the typical form of *T. spiniferus*.

Occurrence.—Seventy-five feet beneath the top of the Athens shale, bluff on north side of Hiwassee River, 1½ miles east of Calhoun, Tenn.

Holotype.—Cat. No. 80538, U.S.N.M.

TELEPHUS SINUATUS, new species

Plate 3, Figure 15

A single cranidium from the Whitesburg limestone at Lexington, Va., reminds in its occipital spine and in the outline and moderate convexity of the glabella of *T. spiniferus*. Possibly it represents a near progenitor of that species, but certain of its features differ so obviously from the corresponding parts of *T. spiniferus* that it seems unwise to refer the Lexington specimen to the same species. Although recognizing the possibility that future collections may bridge the distinctions now so strikingly displayed, the chances that the required intermediate stages may be found are thought to be too remote to warrant ignoring structural differences that if recognized

as separating closely allied but distinguishable forms will add one more to the list of useful guide fossils. Besides, it is thought even likely that the form which it is proposed to call *Telephus sinuatus* is really more closely allied to *T. bipunctatus* and *T. mysticensis* than *T. spiniferus*.

The occipital spine in the holotype of *T. sinuatus* is broken, but enough remains to indicate a length and direction similar to that of the corresponding spine in *T. spiniferus*. As said the outline and convexity of the glabella also is not strikingly different except in its posterior part. Namely, the anterior side of the neck furrow is not straight as usually is the case in species of *Telephus* but curves backward on either side of the middle third, the undulations being due to the imperfect development of a pair of posterior glabellar lobes. The neck furrow therefore is curved in a manner simulating a "Cupid's bow." Other more obscure marks in the slopes of the glabella and which doubtless are related to glabellar furrows are shown in the illustrations in Plate 3, but, as will be observed, there is nothing like the distinct pair of dimples which are so characteristic of *T. bipunctatus*. In fact, although clearly outlined the middle part of the spots is slightly raised instead of deeply impressed.

In the anterior and lateral parts of the outline of the cranidium and in the shape and size of the fixed cheeks *T. sinuatus* agrees much better with *T. mysticensis* and *T. gelasinosus* than with either *T. spiniferus* or *T. bipunctatus*, the general outline being more rounded and the fixed cheeks smaller than in the latter two species.

Occurrence.—The holotype and only known specimen was found in the Whitesburg limestone at Lexington, Va. The Whitesburg in the vicinity of Lexington is very fossiliferous. After years of collecting the total fauna from this bed and place comprises more than 80 species, 30 of them trilobites.

Holotype.—Cat. No. 80540, U.S.N.M.

TELEPHUS BIPUNCTATUS, new species

Plate 5, Figures 1-9

This is by far the most abundant and most widely distributed of the American species of *Telephus*. It is very constant in its characters and perhaps also the best marked. In view of the excellent, and in every respect sufficient, illustrations given on Plate 5 it seems unnecessary to supplement these with a detailed description. However, the more desirable comparisons with other species should not be omitted.

Compared with previously described species only one is at all closely allied to *T. bipunctatus*. This is the Swedish *T. mobergi* Hadding, which also has depressions or pits in the lateral slopes

of the glabella, a small occipital spine, lineate surface markings, the antero-lateral parts of the fixed cheeks subangular and their convex areas pinched into a curved ridge. However, the glabella is not so convex as in our species and relatively not so broad. Besides, the pits on either slope are shallower, not so widely separated, and extended both forward and backward into characteristic long shallow sigmoidally curved furrows that are wanting in the American species. In the latter, on the contrary, the posterior glabellar lobes are outlined in a manner wholly lacking in Hadding's figures of *T. mobergi*. Then, taken as a whole, the length of the cranidium in *T. bipunctatus* is decidedly less than in its Swedish ally, the anterior spines are farther apart and distinctly separated from the adjacent slightly produced angles of the frontal rim, the anastomosing surface ribbing extends over the anterior halves of the fixed cheeks and the anterior as well as the posterior parts of the glabella, and the fixed cheeks, including the palpebral bands, are wider in front and more distinctly triangular in outline.

Compared with American species there are at least four that must be counted as closely related to *T. bipunctatus*. These allies include *T. impunctatus*, *T. prattensis*, *T. tellicoensis*, and *T. hircinus*. The distinctive features of each are given under their respective headings.

The pygidium that is referred to this species is small, triangular in outline, very convex, with very narrow concave pleural lobes and correspondingly large axis. The first ring of the latter carries two small spines near the middle, the second apparently a single though probably a double headed larger node, the third, or terminal ring, which is small and not deeply separated from the second, has a node on each end.

The free cheeks so far discovered with cranidia of this species are all more or less imperfect. The rim is narrow even at the base of the genal spine, of which usually only the stump remains. However, it is retained on the specimen from Lexington, Va., and its strongly curved character, length, and weak base together probably explain its loss in the other specimens. The eyes are large but not so bulbous as in the associated *T. pustulatus*, and the ocular facettes are rather small but not minute as in *T. mysticensis*. They are larger also than in *T. pustulatus*.

Occurrence.—Over 50 specimens of the cranidium of this species were collected from the Whitesburg limestone—a 20 to 40-foot zone of dark gray, irregularly bedded subcrystalline limestone between the Holston marble and Liberty Hall limestone—at Lexington, Va. Only a single pygidium and only one free cheek were observed at this locality. Cranidia occur equally abundant in the corresponding limestone at localities in the vicinity of Albany, Tenn. At these

places a half dozen or so of pygidia—five of them like the one at Lexington, Va.—and one or two imperfect free cheeks were found with the cranidia. Fewer specimens have been found at other Appalachian localities, the most southern being at Pratts Ferry, in central Alabama, in every case in a thin bed of subcrystalline limestone at the base of or rather just beneath the Athens shale.

Cotypes.—Cat. No. 80543, U.S.N.M.

TELEPHUS IMPUNCTATUS, new species

Plate 5, Figures 10-15

This species is based on a number of cranidia that suggest more or less close relations to *T. bipunctatus*, *T. prattensis*, and *T. tellicoensis* without being in any case sufficiently like one or another of the mentioned forms to warrant identification. The general outline of the cranidium is most like that of *T. bipunctatus* from which it is immediately distinguished by the absence of the deep pair of glabellar pits. The glabella is also relatively not so wide posteriorly and its sides less curved, its outline therefore being more conical than in that species. In one of the cranidia referred here (see pl. 5, fig. 13), very shallow and small glabellar pits occur that remind one of *T. bipunctatus*. The proportions of this specimen also differ somewhat from the others, the cranidium being relatively longer. Finally, in all of the specimens that preserve the occipital spine it is stronger than in *T. bipunctatus*.

In general aspect these cranidia remind rather more of *T. prattensis* than of *T. bipunctatus*. In fact the glabella is practically the same as in that species. However, the occipital spine is larger and the fixed cheeks, being wider in front and the outline consequently more sharply recurved, are notably different. In these respects *T. impunctatus* is not much unlike *T. tellicoensis*. The resemblance in this case is heightened by the strength of the occipital spine. But the cheeks are not quite as wide as in that much younger species nor is the occipital spine as strong or directed so much upward, whereas the glabella is distinctly longer than in the *Tellico* species.

Though the cranidia that I refer to this species in a few instances are not very sharply distinguished from those of the species with which they have been compared the case is quite different with respect to the pygidium that was found with them. Though built on much the same plan it is much wider, both as regards the axis and the pleural lobes, and also less convex than are the pygidia found with and assigned to *T. bipunctatus*, *T. hircinus*, and *T. tellicoensis*. As usual the anterior half of the first axial ring carries a pair of small median spines, and the second shows the stump of a single

much larger spine. Unfortunately the posterior extremity of the pygidium is missing, so that its characters remain unknown. The uncommonly wide pleural lobes are covered with very fine striae paralleling the outer edge.

Occurrence.—Whitesburg limestone, near Albany, Tennessee, where it is associated with more numerous specimens of *T. bipunctatus*. Also at Pratts Ferry, Alabama.

Cotypes.—Cat. No. 80544, U.S.N.M.

TELEPHUS PRATTENSIS, new species

Plate 3, Figures 16-19

Associated with typical specimens of *T. bipunctatus* a single small but good cranidium was found in 1910 at Pratts Ferry, Alabama, that departs in important respects from the usual characters of that species. Since then three other but structurally precisely similar cranidia were found in the lower 50 feet of the typical section of the Whitesburg limestone in Tennessee. In certain of their features these specimens approach the three Tellico sandstone species of the genus without, however, agreeing exactly with any of them. For convenience of reference it is thought advisable to give them another name, leaving to the future the decision as to its final and true systematic position.

Compared with *T. bipunctatus* it is distinguished at once by the very slight depth or complete obsolescence of the glabellar pits and absence of any indication of the posterior pair of lobes. Otherwise the glabella is nearly the same as in *T. bipunctatus*, particularly in the matters of outline and general convexity. Comparing other features, however, it is found that the lateral parts of the palpebral band are wider whereas the anterior spines are relatively smaller and less widely separated, the antero-lateral parts of the outline of the cranidium are more rounded, the convex areas of the fixed cheeks are smaller and much narrower anteriorly, and the occipital furrow straighter than in *T. bipunctatus*. These differences impart an aspect to the cranidium sufficiently distinctive to convince one that entire specimens of these trilobites would show equally important peculiarities in the unknown parts.

A closer relative perhaps is *T. impunctatus*, in which the glabella may be said to be precisely similar in form and surface markings. The present species, however, has a much smaller occipital spine, the anterior part of the outline of the cranidium more rounded, and the fixed cheeks decidedly smaller. The last character distinguishes *T. prattensis* from all of the Whitesburg and Tellico species.

As said, *T. prattensis* suggests relations to the Tellico species *T. hircinus*, *T. tellicoensis*, and *T. transversus*, in all of which the glabellar pits tend to partial or complete obsolescence and the anterior rim is relatively wide. However, on further and more critical comparison it differs from all of them in being smaller and in having much smaller fixed cheeks; and from the first in the greatly inferior development of the anterior and occipital spines; from the second in its relatively longer cranidium and glabella and anteriorly narrower and outwardly more rounded (less triangular) fixed cheeks; and from the third in its longer cranidium and glabella, more convex glabella, smaller anterior spines, and smaller as well as more definitely ridged and differently outlined cheeks. The anterior edge also seems to be more arched in anterior view and is decidedly more rounded in outline in dorsal views.

None of the other species is as near in cranidial characters as those mentioned in the above comparisons nor close enough to require further comment. A possible exception would be *T. mysticensis*, in which the fixed cheeks are still narrower, especially anteriorly, and the cranidium as a whole relatively longer and more rounded in outline anteriorly.

Occurrence.—Found with *T. bipunctatus* in a thin bed of subcrystalline limestone regarded as representing the Whitesburg limestone. This bed lies between the base of shaly and argillaceous graptolite bearing limestones referred to the Athens shale and the top of massive beds of Lenoir limestone at Pratts Ferry, Ala. Other specimens from the lower 50 feet of the Whitesburg limestone, about 1.5 miles southeast of Whitesburg and 2 miles southwest of Bulls Gap, Tenn.

Cotypes.—Cat. Nos. 80541, 80542, U.S.N.M.

TELEPHUS TELLICOENSIS, new species

Plate 6, Figures 10–19; Plate 7, Figures 10, 11

The available material of this species affords the nearest approach to a conception of the complete carapace of *Telephus*. The specimens occur in a hard matrix tenaciously adhering to the test. Out of over 50 cranidia about half were prepared for study and found to conform strictly to type. The rock contained also many free cheeks, fewer pygidia, and yet fewer and generally broken thoracic segments.

The cranidium agrees in general and especially in the outline of the glabella and surface markings with *T. bipunctatus* but lacks entirely the pits and other markings indicating glabellar furrows. Further comparisons show among other differences that the occipital spine is much larger, the fixed cheeks somewhat narrower and their

outer edges more nearly longitudinal in direction. Though readily distinguished, it yet appears entirely probable that *T. tellicoensis* is a well modified descendant of *T. bipunctatus*, which is a common fossil in the Whitesburg limestone and, so far as known, confined to it.

The cranium might be compared with those of various other species, notably *T. hircinus*, *T. mobergi*, and *T. prattensis*, in all of which the surface shows raised and more or less anastomosing lines that are characteristic of the *T. bipunctatus* section of the genus. However, it hardly seems worth while to say more than that none of the mentioned species is quite like the present.

The free cheeks are remarkable for two reasons; first, the great size and relatively coarse facetting of the eyes and, second, the invariable presence of two large diverging spines, both springing from the outer side of the narrow rim, one at a point near the middle of the length of the eye, the other a short distance behind it. The eye facets are arranged, as usual, in quincunx, making diagonally intersecting and transverse rows with 13 or 14 of the latter sufficing to cover the highest part. The outer rim is sharply separated from the eye by a deep groove, very narrow in front, wider behind, and widest in the middle third which bears the two large spines. The two figured free cheeks show considerable difference in the form and width of the spine-bearing part, and it is quite possible that the larger of the two belongs to another species—perhaps to *T. hircinus*.

Two very slightly differing kinds of pygidia were found with the foregoing crania and free cheeks. They differ mainly in one being relatively shorter or wider than the other. Most of the greater width of the former is added to the concave and yet very narrow and obscurely defined pleural areas and border. Both kinds have a small triangular flat posterior spine, but this is a little shorter in the wider form, and the edge of the pygidium turns laterally from the spine more abruptly than in the narrower kind. In consequence the outline of the pygidium as a whole is more regularly triangular in the narrower form than in the wider one. Specimens of the cranium of *T. tellicoensis* being much more abundant in the rock than are the parts of associated species, it is thought likely that its pygidia also would occur oftener. Hence, the narrower kind, of which eight specimens were found whereas only two examples of the wider form were observed, is referred to this species. The other may belong to either *T. hircinus* or *T. transversus*, with the probabilities favoring the former.

Only six or seven kinds of pygidia referable to species of this genus have been detected in American deposits. The first of these occurred with the crania of *T. mysticensis*. It has three blunt marginal spines, two of them merely sharp angles, and three axial segments, the anterior of which carries a single low median node. The second

is referred to *T. bipunctatus*. It is slightly wider than the others, seems spineless behind, has but two axial segments, the anterior of which carries two small nodes or short spines whereas the broad posterior one rises apparently into a single larger spine. The third, referred to *T. impunctatus*, is less convex, wider in front (more broadly triangular), and has wider pleural lobes than the others. The fourth, which is doubtfully referred to *T. troedssoni*, probably the nearest American relative of *T. mobergi*, is much like the third in outline, with, respectively, two and one nodes on the anterior and posterior axial rings. The two slightly different pygidia found with *T. tellicoensis* and *T. hircinus* have a posterior spine and two axial segments, with two small nodes on the anterior segment and one, or it may be two, larger ones on the posterior one.

Occurrence.—Tellico formation associated with *T. transversus* in a bed of reddish crystalline limestone 10 feet above the base of the Tellico formation, one and one-half miles southeast of the Southern Railway station in Knoxville, Tenn. In this belt the Tellico rests unconformably on the Holston marble. In the belt next to the east the Tellico still is in contact with the Holston, but the *Telephus* zone lies about 300 feet above the base of the Tellico. In the belt next to the east the Holston is commonly entirely wanting, and where any beds of it are found they are succeeded by from 1,000 to 4,000 feet of Athens shale before the section reaches the base of the Tellico.

Cotypes.—Cat. Nos. 80531, 80532, U.S.N.M.

TELEPHUS TRANSVERSUS, new species

Plate 6, Figures 20, 21

This species is represented by a single good cranidium that was found in association with numerous heads, free cheeks, and pygidia of *T. tellicoensis* and *T. hircinus* in the Tellico formation east of Knoxville, Tenn. Though obviously very closely related, it was at once distinguished from the common associated forms by its even shorter, more transverse form, the lesser convexity, greater posterior width, lowly ridged contour, and flattish slopes of the glabella, and the greater width of the frontal rim. As in *T. tellicoensis*, a very shallow, obscurely defined broad pit lies near the middle of the lateral slopes of the glabella. These pits, though much shallower than the corresponding impressions in *T. bipunctatus*, nevertheless, as does also the cranidium as a whole, remind of that older species. However, critical comparisons indicate other slight differences that help in warranting the specific distinction here credited to the two forms. Thus, the broken base of the occipital

spine indicates a spine of larger size than occurs in *T. bipunctatus*. The anterior spines also are larger, and the rim from which they spring is slightly thicker than in that species. More conspicuous is the greater posterior width of the glabella. Finally, the posterior end of the fixed cheeks is wider, the raised outer edge of the palpebral band correspondingly more longitudinal in direction, the anterolateral angles more bluntly rounded, and the convex area of the cheek more uniformly convex.

Although none of these structural differences is very conspicuous or impressive it is nevertheless true that hardly a single cranidial feature is precisely alike in the two. Now, since the differences have been determined and pointed out it seems unlikely that others will have as much difficulty in distinguishing properly prepared specimens as I had in working them out. Besides, there is always the chance that more striking structural differences may be found in the as yet unknown other parts of the animals. But, after all, the main reason for taking the trouble of determining the differences by which successive stages in the evolution of fossil organisms may be distinguished and recognized lies in the increasingly great need of unquestionable guide fossils.

The present species is related also to *T. mobergi* Hadding, but the differences in this case are too readily determinable by comparison of their respective illustrations in following plates to require further notice here.

Occurrence.—Ten feet above base of Tellico formation at quarry on south side of Tennessee River, one and one-half miles east-southeast of Southern Railway station in Knoxville, Tenn. A few specimens were found also in the Tellico belt next to the east about 6 miles east of Knoxville. At this place the species is associated with *T. hircinus* and a multitude of Bryozoa in an oolitic and ferruginous limestone conglomerate about 300 feet above the base of the formation.

Holotype.—Cat. No. 80534, U.S.N.M.

TELEPHUS HIRCINUS, new species

Plate 7, Figures 1-9

Distinguished from other species mainly by its great posterior convexity, stronger neck spine, thicker occipital ring, the larger size and more anterior direction of the anterior spines, and relatively narrower anterior rim. The glabella is broadly rounded-conical in outline, has somewhat flattened slopes with obscurely defined and very shallow depressions representing the second pair of furrows. Surface nearly smooth with obscure striations on the post-median (highest) part of the glabella and on the anterior slopes of the fixed

cheeks. The latter are of moderate size and convexity and rounded in outline.

T. hircinus is larger than *T. bipunctatus* but evidently is allied to it and may indeed, like *T. tellicoensis*, have been derived from it. However, the characters mentioned will, it is believed, serve satisfactorily in distinguishing them. None of the other species seem close enough to require detailed comparison.

Occurrence.—Rare in a highly fossiliferous ferruginous oolitic and crystalline limestone, about 6 feet thick, intercalated in ordinary calcareous Tellico sandstone in the middle third of the formation, 6 miles east of Knoxville, Tenn. Also in the basal 10 feet of the Tellico in the band one mile southeast of Knoxville. At both places it is associated with *T. tellicoensis* and *T. transversus*.

Cotypes.—Cat. No. 80548, U.S.N.M.

TELEPHUS BILUNATUS, new species

Plate 6, Figures 8, 9

A small species known only from its cranidium. This is relatively longer and rounder than in most others of the genus, has small fixed cheeks with the convex areas of same narrow, carinated, and curved, the glabella strongly convex and, including the neck ring, subovate in outline, with a deep sharply impressed crescentic glabellar dimple in either slope, the neck furrow deep and wide, and the occipital ring but little wider than the furrow with a small posteriorly directed spine and in front of this on the anterior edge of the ring a small conical elevation that may have served for visual purposes. Surface apparently quite smooth.

In general aspect this small trilobite head resembles the corresponding part of *T. mysticensis*, but it is distinguished at once by the strongly impressed crescentic glabellar dimples. These impressions are even more sharply defined than in *T. bipunctatus*, and their outwardly bowed form gives the head so characteristic an appearance as to forbid any thought of its reference to any other of the known species. Hadding's *T. mobergi* may be as near as any, but in that species the antero-lateral part of the outline of the cranidium is more angular, the glabella more depressed convex, and the crescentic glabellar depressions are convex inwardly instead of outwardly.

Occurrence.—A rare fossil in the Whitesburg limestone near Albany, Tennessee. Here it was found associated with many remains of heads and other parts of *T. bipunctatus*.

Holotype.—Cat. No. 80529, U.S.N.M.

TELEPHUS BUTTSI, new species

Plate 5, Figure 16

The holotype of this perhaps doubtful species is a very small cranidium with an extremely long, slender, and rounded occipital spine. Two other, in all respects similar, cranidia were found with it in the same slab of shale. Slight variations in shape of these three specimens and in associated fossils of other classes indicate that the figured holotype has suffered sufficient compression to have reduced its original longitudinal dimensions by possibly a fourth. On realizing this its resemblance to *T. bipunctatus*, which has been noted already by comparison of their respective illustrations in Plate 5, is correspondingly enhanced. Possibly it actually belongs to that species, in which case the extraordinary length of the occipital spine would be merely a character of youth. However, it is not so easy to explain the sharply angular post-lateral extremities of the glabella and also the greater obliquity and more posterior position of the pair of glabellar furrows. The anterior spines also are more divergent and more prominent in dorsal views than in *T. bipunctatus*. For these reasons it seems best to treat these small specimens as representatives of an independent species. It is named for Dr. Charles Butts, who discovered the outcrop of shale in which they and many other interesting fossils were found by him and subsequently by Mr. R. D. Mesler.

Occurrence.—The types of *T. buttsi* and also the specimens referred to the following *T. troedssoni* come from a yellow leached shale at the base of a considerable thickness of dark colored, hence more normal, Athens shale, one and one-half miles northeast of Longview, Ala. With these remains of *Telephus* occur other similarly distorted trilobites—among them *Robergia athenia* Butts and undetermined species of *Agnostus*, *Harpes*, and *Ampyxina*; also *Turrilepas* and various brachiopods. Most of these suggest the Whitesburg limestone horizon rather than typical Athens.

Holotype.—Cat. No. 80546, U.S.N.M.

TELEPHUS TROEDSSONI Raymond

Plate, 5, Figures 17-21

Telephus troedssoni RAYMOND, 1925, Mus. Comp. Zool. Bull., vol. 67, No. 1, p. 66 (not figured).

Cf. *Telephus mobergi* HADDING, 1913, Geol. foren. Forhandl., vol. 35, p. 37, pl. 2, figs. 12-17 (reproduced in pl. 2 of this work).

Raymond's description is as follows:

Cranidium small, moderately convex, with broad flaring palpebral lobes which enlarge toward the front. Glabella ovate, tapering considerably toward the front, bearing only one pair of furrows, which are obliquely directed depressions

which do not connect with the dorsal furrows. The nuchal ring is wide, and bears a long slender median spine. The specimen is a cast of the exterior, and shows a very fine granular ornamentation on the palpebral lobes.

Measurements.—The cranium is 4.00 mm. long and 5.00 mm. wide across the palpebral lobes near the front. The glabella is 2.25 mm. long, and 3.00 mm. wide at the base. The nuchal spine is about 1.25 mm. long.

This species appears to be most closely allied to *Telephus mobergi* Hadding (Geol. foren. Forhandl., 1913, 35, p. 37, pl. 2, fig. 12-17), agreeing with that species in the possession of one pair of glabellar furrows, which, however, are differently placed, and in having ornamentation only on the palpebral lobes.

T. troedssoni differs from *T. americanus* Billings in that the glabella tapers more rapidly forward, and in possessing a nuchal spine.

Horizon and Locality.—A single cranium was found by the writer in Athens shale associated with *Nemograptus gracilis* in a cutting on the railroad 2 miles northeast of Athens, Tenn. Named for Dr. Gustav Troedsson who was with me when the species was found. Holotype (M. C. Z. 1,723).

Study of Raymond's poorly preserved holotype of this species and of the clay mold of it that is illustrated in Plate 5, Figure 17, suggests that it is really a closer ally of Hadding's *T. mobergi* than is indicated by the above quoted description. The exterior ornamentation of the fixed cheeks, or palpebral lobes as Raymond calls them, is nearly obliterated, but its remains leave little doubt in my mind that it was not of the granular kind but rather of the reticulated type that occurs in *T. mobergi* and is perhaps best developed in such American species as *T. bipunctatus* and *T. prattensis*. Certain obscure thin longitudinal ridges on the posterior half of the glabella also suggest remains of the kind of ridging of the corresponding parts of the exterior surface of the head that prevails in the mentioned Swedish and American species. Neither the reticulation of the cheeks nor the longitudinal ridges of the glabella seem ever to show on clean casts of the interior.

A few more or less distorted specimens, comprising a couple of crania, a free cheek, and a pygidium from basal Athens near Longview, Ala., that prior to seeing the type of *T. troedssoni* I had referred with question to *T. mobergi*, may very well be conspecific with Raymond's species. There are some differences when we compare these Alabama specimens with the illustrations of the mentioned Swedish species on the one hand and with the type of *T. troedssoni* on the other. But since the latter species has been established and though closely related to is yet distinguishable from *T. mobergi*, and as I find it easier to explain the observed accidental differences from the type of *T. troedssoni* than I can account for the differences noted in comparing the Alabama specimen with the Swedish species, it seems best for the present to refer them to Raymond's species.

A few statements regarding each of the Alabama specimens here under consideration and illustrated on Plate 5 may be desirable.

Figure 18 is of a cranidium that obviously has been distorted by reduction of its original transverse dimensions. Its interest lies particularly in the preservation and clear separation of the two pairs of anterior spines. These spines are only very obscurely indicated in the holotype of the species shown beside it in Figure 17.

Figure 19 is an untouched photograph of a distorted and incomplete free cheek. It probably belongs to this species, this opinion being mainly based on the fact that it reminds of the cheeks of *T. mobergi* and *T. bipunctatus*, both of which must on other grounds be viewed as close allies of *T. troedssoni*.

Figure 20 also is an untouched photograph of a cranidium that can be referred to this species only provisionally. Though doubtless much distorted by compression that has reduced its original longitudinal dimensions by perhaps as much as a third, it is hardly conceivable that its present shape could have been achieved by compression of a cranidium like that of either Figure 17 or 18 in the same plate. Though the surface of the glabella shows some irregular undulations none of the slight depressions could represent the dimple-like furrows that occur on those cranidia. It probably represents a form more nearly like that of such younger species as *T. hircinus* and *T. tellicoensis*, in which the glabella is without furrows.

Figure 21 is taken from an associated pygidium. Though the original indicates reduction in length by compression of the shaly matrix the width of the border behind the axis is still notably greater than in any other species of the genus of which the pygidium is known. Though possibly the tail of the associated *T. buttsi* its reference to *T. troedssoni* seems the most likely to prove correct.

Plesiotypes.—Cat. No. 80477, U.S.N.M.

Genus GLAPHURUS Raymond

GLAPHURUS PUSTULATUS (Walcott)

Plate 7, Figures 15, 16, Plate 8, Figures 1-11.

Arionellus pustulatus WALCOTT, 1880, 31st Ann. Rep. New York State Mus. Nat. Hist., p. 68; adv. sheets of same 1877, p. 15.

Sao (?) *Lamottensis* WHITFIELD, 1886, Bull. Amer. Mus. Nat. Hist.; 1. p. 334, pl. 33, figs. 9-11.—BRAINERD and SEELY, 1890, Bull. Amer. Mus. Nat. Hist., 3, p. 22.—LESLEY, 1889, Geol. Surv. Pennsylvania Rep., P. 4, p. 825, figs. (copied from Whitfield.)

Agraulos (*Arionellus*) *pustulatus* VOGDES, 1890, Bull. U. S. Geol. Surv., No. 63, p. 90.

Glaphurus pustulatus RAYMOND, 1905, Ann. Carnegie Mus., vol. 3, p. 357, pl. 14, figs. 4-6; 1910, vol. 7, p. 74, pl. 18, figs. 9-11; 1910, 7th Report Vermont State Geol., p. 234, pl. 36, figs. 4-6, and pl. 38, figs. 9-11; also Grabau and Shimer, 1910, and Perkins, 1912, who reproduces Raymond's figures of the species.

As the previously published illustrations of this interesting and extremely spinose trilobite are not very good and fail to bring out

some of its most important structural features I have endeavored to supply the desired information by devoting nearly an entire plate to the illustration of its parts. The accurately figured specimens shown in Plates 7 and 8 do not include either of the two complete individuals that are comprised in the material before me but consist mainly of separated parts of the dorsal shield that show many previously unrecorded details of structure. Most of these features are mentioned in the descriptions of the figures in the plates to which the reader is referred. However some of them deserve further discussion here.

To begin with I will call attention to the extremely spiny nature of the surface of the cephalon and thorax. The pygidium, on the contrary, has no spines but its surface is covered with very small tubercles. Of course, as a rule only the broken stumps of these spines are to be seen on the specimens as they show on the fractured surface of the fine grained limestone matrix. It is only here and there, as for instance at the left end of the occipital ring of the cranium in the left half of figure 2, that one gets an adequate conception of the great length and extreme slenderness of many of these spines. The length of those on the pleural parts of the thoracic segments is shown on the right side of figure 1. Those on the axis appear to be shorter.

The ends of the thoracic segments, of which there are 10, are not drawn out into recurved spines, as indicated in Whitfield's figure of the thorax, but are simply turned sharply downward and terminate somewhat bluntly and obliquely, the free edge being lined with a fringe of minute spines, the posterior one of which is thicker and much longer than the others.

Another set or fringe of very small spines that seems to have been overlooked previously occurs, as shown in figure 4, along the outer edge of the free cheek. Regarding the free cheeks it should also be observed that the two, as shown in figure 5, are connected across the front by a narrow, parallel-sided, double-ure-like band. However, this band seems to be separated from the rim of the dorsal part of the test by a suture along the anterior edge of the cephalon. The strong arching of the edge of the cephalon in the anterior view and the two relatively strong spines on the anterior rim of the cranium are other noteworthy features.

The facial suture cuts the posterior margin immediately behind the base of the genal spine. In fact it seems to cut off a bit of the base of the spine. Anteriorly it cuts the rim just outside of the lateral extremity of the glabella.

Among many strictly specific characters is the fact that there are constantly three transverse rows of spines on the preglabellar field.

So far as known *Glaphurus pustulatus* is confined to a narrow, sometimes reef-like zone that I believe lies at the base of the Upper Chazy limestone at Isle La Motte and other places in the Champlain Valley.

Paratypes.—Cat. No. 88051a-h, U.S.N.M.

GLAPHURUS LATIOR, new species

Plate 8, Figures 12, 13

This name is proposed for a rare southern Appalachian representative of the genus of which only the cranidium has been found. It attained larger dimensions than *G. pustulatus* and differs structurally from it mainly in that the cranidium is relatively wider posteriorly and that there are only two instead of three transverse rows of spines cross the middle part of the preglabellar field. Other small differences may be observed in comparing the figures of the two species in following plates.

Occurrence.—The holotype was found in the Whitesburg limestone, 6 miles southwest of Bland, Va. Another was found with *Telephus bipunctatus* at Pratts Ferry, Ala.

Holotype.—Cat. No. 80552, U.S.N.M.

GLAPHURINA, new genus

Glaphurus part RAYMOND, 1925, Mus. Comp. Zoöl. Bull., vol. 67, No. 1, p. 130.

Raymond included at least one of the species referred to this new genus in *Glaphurus* when he described *Glaphurus decipiens* in the work above cited. In the description of the mentioned species he speaks also of southern Appalachian specimens of cranidia that he identifies with it. One of these he collected from a limestone southeast of Bluff City, Tenn., that he calls "Lower Lenoir," and this most probably is the form for which I am proposing the name *Glaphurina falcifera*. The other he obtained "from the Holston limestone in the Catawba Valley, north of Salem, Va.," and this may be of the species for which I am proposing the name *Glaphurina brevicula*. That these two southern cranidia are not strictly conspecific is rendered highly probable by the widely different zones in which they were found. If they are, as I think, clearly distinguishable, stratigraphic considerations demand their separation under names of their own. With such loose identifications of fossil species progress and definite results in working out the sequence of Ordovician deposits and events in the Appalachian Valley, or indeed any where else, are simply impossible.

Whether either of these southern Appalachian Valley species is the same as the Mingan Islands species can not be determined without direct comparison of specimens. Now I can say only this, that

if the figure of "a nearly complete cranidium," which presumably represents the largest of the four cranidia collected by Professor Twenhofel on Bald Island, is reasonably correct, it can not be the same species as either of the southern forms nor the same as the Champlain Valley species that I am calling *Glaphurina lamottensis*. Still, I see no reason to doubt that the Mingan Islands species also belongs to this genus and, if the new genus is accepted, it will hereafter be known as *Glaphurina decipiens*.

These apparently four species all differ from true *Glaphurus* in lacking the preglabellar field which in that genus intervenes as a broad spinose band between the glabella and the anterior furrow and rim. They differ further in lacking the anterior glabellar furrow though a suggestion of it occurs in *Glaphurina falcifera*. Finally the surface of the cranidium is merely pustulose and not spiny as in *Glaphurus*.

Genotype.—*Glaphurina lamottensis*, new species.

Occurrence.—Lower and Upper Chazyan, Champlain Valley, Mingan Islands, Virginia, and eastern Tennessee.

GLAPHURINA LAMOTTENSIS, new species

Plate 8, Figures 14-16

Two cranidia, neither complete yet both in reasonably good condition, are available of this species. The three views of the larger are as nearly correct as they could be made. They fail mainly in that the smaller set of surface pustules, or rather small granules, which are scattered between the larger set and clearly visible in the photographs, do not show in the halftone reproduction. In the tri-convex anterior outline and in the general form of the glabella the dorsal views of these cranidia resemble Raymond's figure of *G. decipiens* but the sides of the glabella are more curved and more convergent to the front so that the glabella is narrower anteriorly and less quadrate and the middle part of the tri-convex anterior outline of the cranidium shorter than it appears to be in the typical form of Raymond's species. If the concerned parts are accurately represented in that illustration it seems improbable that these Champlain Valley specimens can be of his species.

Comparison of their respective figures on Plates 7 and 8 shows clearly enough that *G. lamottensis* is quite distinct also from both *G. brevicula* and *G. falcifera*. As will be mentioned in following notes on the latter there is another as yet unnamed species in the bed that supplied the types of *G. falcifera* that is a nearer ally of *G. lamottensis* than either of the named forms from southern Appalachian localities.

Occurrence.—Associated with numerous specimens of *Glaphurus pustulatus* in the basal bed of the Upper Chazy on Isle La Motte, Vt.

Holotype.—Cat. No. 80553, U.S.N.M.

GLAPHURINA BREVICULA, new species

Plate 7, Figures 17-19

This species is based on a single imperfect cranidium that has a shorter glabella than any of the other species assigned to this genus and seems to differ also in other details from them.

Occurrence.—Holston limestone, 2 miles northwest of Lexington, Va.

Holotype.—Cat. No. 80549, U.S.N.M.

GLAPHURINA FALCIFERA, new species

Plate 7, Figures 20, 21

Of this species we have four cranidia, all more or less imperfect in outline. The glabella is nicely rounded in front and wider in its anterior third than in the other species of the genus. The glabellar depressions also differ in details, the posterior one being double and its parts so arranged that they form a crudely executed figure resembling a sickle that suggested the specific name. As will be noted in studying figure 21, there is a shallower depression in front of the deeper ones. Together they suggest and probably represent the usual first, second, and third pairs of glabellar furrows. The glabella and fixed cheeks are covered with regularly spaced tubercles of moderate and approximately equal size.

With these typical specimens occurred another cranidium in which the sides of the glabella converge more rapidly forward, the glabellar pits apparently a single, altogether more simple pair, and the surface tubercles distinctly of two sizes, with most of those covering the glabella, the posterior slopes of the fixed cheeks and the middle part of the occipital ring decidedly smaller and much more crowded than in the holotype and other specimens that are included in the types of the species. In the mentioned respects this unique cranidium comes closer to *G. lamottensis* than to *G. falcifera* without, however, being enough like the former to be regarded as the same species. Evidently the Lower Chazy of Tennessee contains a second species of *Glaphurina* that remains to be figured and named. Unfortunately its sole known representative had not been discovered when the plates of the present paper were made up.

Occurrence.—Found in an as yet unnamed Lower Chazy limestone formation that underlies a typical but thin development of the Lenoir limestone and rests unconformably on the Middle Cana-

dian *Lecanospira* zone on Indian Creek, one and a half miles southeast of Bluff City, Tenn.

Holotype.—Cat. No. 80550, U.S.N.M.

STRATIGRAPHIC AND GEOGRAPHIC RANGE OF *TELEPHUS* AND
CORRELATION OF FORMATIONS

Range and origin of Telephus faunas.—In the Appalachian Valley remains of *Telephus* are confined to areas in the eastern half of the valley south of Staunton, Va., and in the north to a few places in southeastern Canada. All these occurrences are in faunas that are clearly of Atlantic (Poseidon) origin. This conclusion is based mainly on two facts: First, that *Telephus* and nearly all of the remainder of the faunas in which species of this genus of trilobites occur are wholly absent in the Ordovician deposits in most of the western half of the Appalachian Valley. The latter, on the other hand, agree in lithic and faunal characters with the Ordovician deposits in the Ohio Valley. Second, the faunas of the Blount group, which include species of *Telephus* and many other genera that are found in America only in the eastern belts of the Appalachian Valley, are represented by very similar and in some cases perhaps indistinguishable species in related and in part perhaps contemporaneous formations in southeastern Canada, Scotland, Norway, Sweden, and Bohemia.

In Virginia, Tennessee, and Alabama the first appearance of *Telephus* is in the Whitesburg limestone. It is this formation also that gave us 8 of the 15 or 16 species described in this paper from southern Appalachian localities. Of the remaining species five came from overlying Athens shale and three from the succeeding Tellico. The vertical range of the genus therefore seems as well fixed in the sequence of Upper Chazy deposits in the Appalachian Valley as in its geographic range. Further, in view of its restricted occurrences in the St. Lawrence Valley and Newfoundland and, on the other side of the Atlantic, in southern Scotland, Sweden, Norway, and Bohemia it seems fairly clear that the type originated in and dispersed from the middle Atlantic basin.

In America, as in northeastern Europe, *Telephus* is often associated with species of such other genera of trilobites as *Ampyx*, *Lonchodorus*, *Ampyxina*, *Roborgia*, *Remopleurides*, *Dionide*, *Salteria*, *Trinucleus*, *Bronteopsis*, and *Nileus*, all of which I regard as also indigenous to the middle Atlantic Basin. None of them has been found in Cordilleran faunas or Chazy or younger Ordovician ages that were developed in the Arctic and Pacific realms nor in the Ordovician faunas in the Mississippi and Ohio Valleys that are thought to have invaded the continent from the south. Nor have they been found in the typical Chazy in the Champlain Valley or,

with the exception of *Lonchodonus* and *Remopleurides*, in the Lower and Middle Chazyan and the Holston and Ottosee formations of the Blount group in the southern Appalachian belts. Separation of Paleozoic faunas according to their geographic origin is discussed at considerable length in following pages.

Trilobites preferred to graptolites in trans-Atlantic correlations.—In my estimation *Telephus* and the other above-mentioned genera of Atlantic trilobites are at least as dependable criteria as the highly esteemed graptolites in correlating formations in America with those in Europe. Still these problems are never simple; and too often the fossil evidence is not as definitely indicative of time relations as it may seem. In a recent paper¹⁸ I showed that the graptolites—mainly because their preservation is usually too imperfect to permit of the required intensive study and comparison of minute structural details—are as yet only a rather coarsely graduated standard of measurement. Nor is the evidence of the trilobites or of any other class of fossils easily evaluated. Closely similar species are found on the two sides of the Atlantic, but other means must be employed before we may be warranted in concluding that the observed slight differences between the compared forms indicate merely locally developed contemporary modifications or that they are variations from type that required long periods of time to produce. And even when two occurrences on opposite sides of the sea can not be satisfactorily distinguished the fact by itself is not determinative as to their practical contemporaneity unless the remains are complicated in structure and they agree in biblogically unimportant structural features.¹⁹ It is only after the finest possible differentiation of congeneric species or varieties has been carried out that detailed correlation of their respective zones is validly permissible.

In the Appalachian Valley, from central Alabama to, say Staunton, Va., the occurrence of specifically identical forms of the trilobite genera mentioned above may be accepted as reasonably conclusive proof of the essential contemporaneity of the beds containing them. Corroboration of the validity of this conclusion is found in the fact that the species of *Telephus* and other genera of trilobites that are regarded as belonging only to the zone of the Whitesburg limestone are always found only beneath the lowest occurrence of the Normanskill graptolites and of the trilobites that in southern Appalachian belts commonly occur either in the same layers

¹⁸ Relative values of criteria used in drawing the Ordovician-Silurian boundary, *Geol. Soc. America Bull.*, vol. 37, p. 301, 1926. Because they tend to amplify facts presented in this paper concerning differences on the two sides of the Atlantic in the vertical range of graptolites that in Britain are regarded as reliable horizon markers it seems worth while to direct the reader's attention to paragraphs on pp. 179 and 180 of Troedsson's 1928 work on the Middle and Upper Ordovician Faunas of Northern Greenland.

¹⁹ See Ulrich, E. O., Correlation by displacements of the strand line, *Geol. Soc. America Bull.*, vol. 27, p. 488, 1916.

with the graptolites or by themselves in the basal quarter of the Athens shale. This is true whether the Athens consists entirely of the shale facies or begins with or consists entirely of the limy facies. The case, however, is very different when we try to fix the position of the *Telephus* occurrences in southeastern Canada in the sequence of Chazyan deposits in the southern Appalachian troughs. The species in the former region are not precisely the same as their congeners in the south. None of the latter could be unquestionably identified with *T. mysticensis*, which is the name proposed in the paleontological part of this paper for the species found in the limestone conglomerate near Mystic in the southwestern corner of Quebec.

Absence of Telephus faunas in Champlain Valley.—Except the Valcour limestone, which is the top limestone of the Chazy in the Champlain and St. Lawrence Valleys and probably falls into some undetermined part of the stratigraphic span covered by the Blount group of east Tennessee, no deposits of Blount age occur in place between Virginia and the Mingan Islands in the Gulf of St. Lawrence. Disregarding the Valcour—mainly because its fauna is quite dissimilar to all but the highest (Ottosee) fauna of the Blount—we may therefore assume that the Appalachian troughs north of Virginia and south of Canada were emerged during the deposition of the 6,000 feet or more of beds comprised in the Holston, Whitesburg, Athens, and Tellico formations of east Tennessee and in the second, third, and fourth of which remains of *Telephus* are found. If we were to assume that the Tellico occurrences of *Telephus* marked the termination of the existence of the genus we might then conclude that the occurrences of the genus in Canada and Europe are older than the top of the Tellico. But we would have to assume or prove also that the foreign occurrences are not older than the Whitesburg limestone before we could say that any of the concerned Chazyan formations on the two sides of the Atlantic are contemporaneous.

Discussion of age relations of faunas in Scotland to Appalachian faunas.—On the basis of direct faunal comparisons it seemed at first one might find sufficient evidence to indicate that the Balclatchie group in the Girvan District in Scotland—from which Reed described *Telephus salteri*—comes nearer to an agreement with our Whitesburg limestone than with any other of the Appalachian formations. Corroboration of this suggested correlation appeared also in the fact previously pointed out by Raymond²⁰ that species of *Dionide* occur

²⁰ Raymond, P. E., Some trilobites of the Lower Middle Ordovician of eastern North America: Harvard Coll. Mus. Comp. Zool. Bull., vol. 67, No. 1, p. 179, 1925.

in the Girvan District only in and perhaps above the Whitehouse group, which succeeds the Balclatchie, whereas in America the genus is confined to the Athens shale, which succeeds the Whitesburg. However, after seeing the concerned beds in Scotland and reconsideration of the evidence in the light of personal observation of facts not previously available to me, the suggested correlation of the Balclatchie and Whitesburg has become quite impossible. In fact, nothing is left of it than the conviction that the faunas of the two formations were derived from the same Middle Atlantic realm. But they did not receive them at the same time, the Balclatchie invasion of Scotland having occurred long subsequent to the Whitesburg, and after considerable modification and change of the earlier composition of the Middle Atlantic fauna had been introduced. The probable truth of this statement is rather plainly indicated by the fact that not a single species has been found in either formation that is strictly the same as any in the other. Also by the fact that the Balclatchie fauna includes many types that are unknown in Appalachian faunas that contain species of Middle Atlantic origin and are of older dates than the Ottosee, Little Oak, and Chambersburg faunas. The latter fact thus tends to confirm the conclusion that is more satisfactorily substantiated by considerations about to be presented.

In the first place, the lower age limit of the Balclatchie may be said to be conclusively fixed—at least in the minds of British geologists who rely so strongly in their Lower Paleozoic correlations on the evidence of graptolites—by the fact that it is underlain by a shaly zone that contains Glenkiln graptolites. The Glenkiln, as all agree, represents the Normanskill and Athens shales of the Appalachian geosyncline. It follows, then, that the Balclatchie is not only younger than the Whitesburg but also younger than the Athens. Following this conclusion it seemed at first that the Balclatchie might be correlated with our Tellico. This correlation found considerable support in the similarity of the pelecypodan parts of the faunas of the two formations; but again the entire lack of specific identities casts doubt on its validity. Besides, the numerous brachiopods of the Balclatchie include many species that not only look younger than Tellico representatives of the class but indicate a stronger commingling of northern and Middle Atlantic types than we have reason to believe occurred before the close of Blount time. I may mention, too, that the inconspicuous development of the glabellar furrows and the presence of a nucal spine in the Balclatchie *Trinucleus subradiatus* Reed suggests a *Cryptolithus* rather than a *Tretaspis*, to which genus it is referred by Stetson.²¹ Similar species occur in America only above the Chazyan.

²¹ Stetson, H. C., The distribution and relationships of the Trinucleidae: Harvard Coll. Mus. Comp. Zool. Bull., vol. 78, No. 2, p. 88, 1927.

Probably a more important fact is the recent discovery of excellent specimens of a species of *Salteria*—which I propose to name *Salteria oderi* after its discoverer—in a shale formation of Black River age near the Massanutten Caverns in northern Virginia. This new American species is a close but distinguishable ally of the Balclatchie type of the genus, *S. primaeva* Wyville Thomson. The vertical range of this genus in both Scotland and America being very limited the correlation significance of its two known species may well be more definite than is that of allied species of more prolific and more persistent genera common to Britain and North America.

The American species of *Salteria* was found in an elsewhere as yet unknown and geographically probably very limited formation of mainly soft yellow or yellowish-gray calcareous shale, 300 to 400 feet thick, that lies directly beneath a great mass of darker Martinsburg shale (Trenton and Cincinnati) and rests apparently without intervention of other deposits on a fair development of Athens shale. Absence of the missing beds in this area is not extraordinary because it has been known for 20 years that the Athens is the only formation of the Blount group that extends so far north in Virginia.

This new formation has already provided many new fossils besides *Salteria oderi*. Among them I may mention 8 or 10 species of graptolites, 1 or 2 species of *Tretaspis*, 2 species of *Calymene*, a species of *Encrinurus* allied to *E. punctatus*, a *Tornquistia*, and a *Dalmanella*. The brachiopod and all of the trilobites are more or less closely related to Balclatchie species. Moreover, the species of *Calymene* mark the first appearance of their generic type in both North America and southwestern Scotland. The graptolites are of particular interest and stratigraphic significance in showing intermediate stages of development between those prevailing in the Normanskill and Athens and those marking Trenton stages. The only reasonable conclusion to be reached from my study of this fauna is that it represents an invasion of the Appalachian trough by a Middle Atlantic fauna during some Black River age that, so far as known, left no depositional record elsewhere in North America.

In view of these facts and logical deductions I feel impelled to give the Balclatchie a higher position in the American section than I formerly believed warranted. Perhaps it should go even a notch higher than I have given it in the correlation chart on page 73.

To further illustrate the difficulties of correlating Ordovician and Silurian formations on opposite sides of the Atlantic seems worth while to give a brief account of the blind trails followed before I knew positively that the Balclatchie is underlain by shale with Glenkiln-Athens graptolites. Naturally, I began the present inquiry with a detailed study of Reed's monographs of the fossils of the Girvan district. The Drummuck seemed fairly easy, but none of the three

underlying formations, Whitehouse, Balclatchie, and Stinchar—the brachiopods and trilobites of which he described—seemed to offer any decisive clues at all. In the case of the Stinchar, as is rather fully brought out in the notes on the British column of the correlation table (see p. 84), the amazingly contradictory faunal evidence included in Reed's list of its fossils served mainly in upsetting every hypothesis that suggested itself. Then after noting the large proportion of species said to be common to the Stinchar and the Balclatchie and at the same time the species in both that should, according to American standards, be much older, I could only assume that either many types began much earlier in Scotland than in our sequence of formations or as many or more began much later. Considering that Reed recognized the relations of the Girvan faunas as closer to those of America than usual with British faunas this state of affairs seemed inexplicable. Something appeared to be wrong but what it might be could not be determined till my visit to Scotland the past summer and after the discovery of new evidence in northern Virginia a few months before.

However, in seeking to force some conclusion out of the tangled skein of fossil evidence I directed my efforts particularly to the trilobites in the Balclatchie and the Whitehouse lists. These gave the impression that the Balclatchie is as old as the Whitesburg or at least not younger than the Athens. This possible conclusion was suggested by the following facts: First, the nearest allies of the Balclatchie species of *Ampyx* and *Lonchodomus* seem to be those found in the Whitesburg limestone and in the Athens shale. The Whitesburg also contains a trilobite very similar to *Tornquistia* cf. *nicholsoni* Reed, a Keisley limestone species identified by that author in both the Balclatchie and the Whitehouse of the Girvan district. Another fact that was given some weight is the occurrence of several species of Acidaspidae in the Whitesburg limestone of Tennessee and Virginia that fall into Raymond's new genus *Onchaspis* and are closely similar to species described by Reed as found in the Balclatchie. Then there is the Balclatchie species *Remopleurides barrandei*, which again is much like some of our Whitesburg and Athens species.

The Scotch species of *Telephus* also seemed to point to some perhaps low horizon in the Blount. The older of the two, *T. salteri* Reed, was found in the Balclatchie. But the holotype of this differs so much from all other species of the genus that I am still at a loss to decide which of them it resembles most. For the present then its significance in stratigraphical correlation is inappreciable. The other species is credited to the Whitehouse group and was referred by Reed to the Bohemian genotype, *T. fractus*. Study of the specimens in the British Museum that were used by Reed has convinced me that

this Girvan species of *Telephus* is neither the same as Barrande's type of the genus nor precisely like any of the other European and American species. I have therefore proposed the new name *Telephus reedi* for it. On comparison with other species it proved to be more nearly related to the Swedish *T. wegelini* and the Athens *T. latus* than to *T. fractus*. Whatever bearing *T. reedi* may have on the question of the stratigraphic relations of the Girvan formations to Appalachian deposits it seemed—as did also the already mentioned alliances of Balclatchie and Whitehouse species of *Ampyx*, *Remopleurides*, *Dionide*, and *Onchaspis*—to favor correlation of the Balclatchie and the Whitehouse with the lower formations of the Blount group. And this conclusion was indicated also by the apparent trend of the evidence of the trilobites—a group of animals that undeniably is more highly organized than the brachiopods and therefore expected to offer the more exact correlation data; a supposition that in this instance failed to be substantiated. However, in justice to the trilobites, it must be admitted that some of the compared species suffered greater disadvantages than the brachiopods in requiring comparison of more or less fragmentary specimens.

With such contradictory, and in other respects indecisive fossil evidence, the formerly existing extreme difficulty of satisfactorily correlating the Ordovician and Silurian formations of Europe with those in America is evident. However, with the developments of the present year, partly described on preceding pages and supplemented in notes on the British column of the following correlation table (see p. 83), the chances of finally reaching fairly definite results seem much more promising than they were a year or two ago. In fact, though still speaking in somewhat generalized manner, we are now probably warranted in correlating the typical Stinchar limestone²² with the Lenoir limestone and the shale with Glenkiln graptolites that lies between the Stinchar and the Benan conglomerate with some part of the Athens shale of the Blount group. The succeeding Balclatchie, Ardwell, and Whitehouse groups are less definitely referable to positions in the Appalachian sequence. Still, I feel reasonably certain that they are post-Chazy in age and that the positions to which they are tentatively assigned on the correlation chart are, if not quite correct, at least nearer the truth than were the conclusions respecting their relations to American formations published a few years ago by Raymond²³ in the stratigraphic part of his work on Ordovician

²² For reasons given on page 84, the designation "typical Stinchar limestone" does not include the doubtless much younger limestone of the Craighead quarry which supplied by far the greater part of the fossils mentioned in Reed's lists of Stinchar limestone trilobites and brachiopods besides many other species of classes, especially corals, not monographed by him.

²³ Raymond, P. E., Harvard Coll. Mus. Comp. Zool. Bull., vol. 67, No. 1, pp. 163-180, 1925.

trilobites of eastern North America and in a more recent paper by the same author and Willard on Chazyan brachiopods in Tennessee and Virginia.

The need of studying the papers on Appalachian brachiopods by Raymond and Willard arose only since the completion of the present work. The new species described and others identified in these papers attain the respectable total of 73 species. It is to be noted also that the species have been discriminated with uncommon attention to external details of shell structure. Still it is evident that their collections from the Chazyan deposits in the southern Appalachian Valley and those from the Stones River limestones in central Tennessee are far inferior, both as regards quantity and quality, to those accumulated in the National Museum by me and my associates. With more and better material probably neither Raymond nor Willard would have identified so many of the Virginia and Tennessee species with Champlain Valley Chazyan and Mississippi Valley Stones River and Black River species. It seems probable also that they would have found that some of the identified or supposedly closely allied species are even only doubtfully assignable to the same genera. But my strongest criticism of both the brachiopod and the preceding trilobite paper concerns the stratigraphic assignments of many of the species. I have studied and collected from all the Virginia and Tennessee localities mentioned in these papers and therefore am prepared to say that many of the asserted occurrences of strictly the same species in two or more of the Chazyan formations are based on mistaken identifications of beds. Indeed, these stratigraphic inaccuracies are so numerous that they very seriously impair the validity of Raymond's conclusions²⁴ regarding the relationships of the Chazyan fossils of Tennessee and Virginia.

Cause of difficulties in correlating European and American Ordovician formations.—Aside from erroneous or merely loose identifications of fossils and misunderstandings, the main cause of our troubles in this connection lies in the indisputable fact that we are dealing with successive and slowly modifying aspects of the generally very different faunas of particular oceanic realms that at times invaded European epicontinental basins and at the same or, more probably, at other times invaded inlets to Appalachian troughs on the western side of the sea. Under the belief that these invasions occurred mostly at alternating intervals on the two sides of the Atlantic—in other words, when emergent conditions were prevailing on the other side—it follows that the sequence of beds and faunas in any one of the areas in which deposits of Ordovician waters that invaded from, say, the Middle Atlantic sea occur can represent only

²⁴ Raymond, P. E., Mus. Comp. Zool. Bull., vol. 70, pp. 300-309, 1928.

a part, and in Europe usually only a small part, of the total time involved. This conclusion applies to the whole of Ordovician time and to invasions of very different northern and southern faunas as well as those that were at home in the Middle Atlantic. Europe, particularly northern Europe, seems to have only graptolite-bearing shales of Athens age to represent the great accumulation of marine deposits included in the Blount group in east Tennessee and southwestern Virginia. Middle Chazyan seems to be represented in the Girvan District of Scotland but can not be positively recognized elsewhere in Europe. The *Orthoceras* limestone of Norway, Sweden, and the Baltic region may correspond to our Lower Chazyan, but, for reasons than can not be readily given at this time, I am inclined to correlate it with some part or parts of our Buffalo River series. Should this belief be substantiated there would be little or nothing left in Europe to set opposite our Lower Chazyan. And so it goes. North America has many Lower Paleozoic formations that at best are weakly represented by sedimentary marine deposits in Europe, whereas those in Europe seem in most cases not strictly correlatable with ours. Their time relations seem to interfinger.

Another important factor that may be largely responsible for some of our difficulties in understanding and properly correlating European formations with those in America is the probability that the prevailing correlations that are carried from one to another of the European exposures of Lower Paleozoic deposits are seldom strictly correct and often decidedly in error. In America we have proved that because of oscillation of the surface of the continent and the shallowness of the marine invasions the successive deposits in the varying Appalachian troughs and basins and in the broader basins of the interior areas are but seldom on the same stratigraphic plane. In other words, the bodies of water in which the deposits were made were patchy and often shifted from one negative area to another, thus being much less extensive at any particular time than was believed formerly. Most probably very similar conditions obtained in Europe also. Indeed, after seeing most of the Scandinavian and British exposures of early Paleozoic rocks, I am thoroughly convinced that the epicontinental seas in which they were laid down were localized and shifted about from time to time in essentially like manner and frequency as we have every reason to believe they were in America. Naturally, then, the sequences of deposits and of the times represented by them in each of the several areas in which negative tendencies are dominant vary more or less from place to place. If the European geologists in studying their Paleozoic deposits will stress differentiation of the beds and fossils of different basins, rather than continue to emphasize their points of

similarity, information regarding the geological history of their several countries will proceed to grow more rapidly than it has in the past 50 years.

Discussion of relative amounts and rates of deposition of Ordovician formations.—It has been suggested to me in recent years that the great thicknesses attained by many of the Paleozoic formations in the southern half of the Appalachian geosyncline indicate a more rapid rate of deposition there than in other areas that received much thinner sequences of deposits during the same geologic periods. But I see no valid reasons for believing this. In my opinion the difference in this respect between them is not so much in the rate of deposition during times of submergence as in the relative frequency and duration of such times. For instance, the 2,000–4,000 feet of calcareous shale and limestone that commonly make up the Athens formation required a long time to lay down; and in my estimation they were laid down no faster than were similar but much thinner beds in the Mississippi and Ohio valleys. The process of deposition in the latter was more often interrupted and, between the interruptions, of shorter duration; but during the times when it was going on the average rate at which the sediments were laid down was not much slower than in the case of the Athens. Of and in these, doubtless, the average rate to the foot was much faster than in most other places. But in those places where sandstones enter to any considerable amount into the process of Athens deposition, as to the east of Abingdon, Va., the thickness of the formation increases correspondingly to as much as 10,000 feet or possibly much more.

This general statement is made in full recognition of the rather obvious fact that whatever the kind of marine deposit, be it mainly or wholly of limestone or shale or sandstone, local conditions must have affected and caused variations in the rate of deposition, whether inference ascribes them to lack or uncommon availability of clastic material or to relative deeps or to deposition in shallow basins or troughs in which interruption of the process was likely to occur frequently; and at times the interruptions persisted through long periods. Thus, only a few miles west of the thickest development of the Blount formations in east Tennessee and southwestern Virginia they pinch out completely, their place in the sequence of formations being in a tight contact between Stones River and Lowville limestones that remain in contact to the Mississippi River and contain wholly distinct faunas of southern and not middle or north Atlantic origin. Moreover, the Stones River wedges out eastwardly beneath the Blount, and its lower formations interfinger in the same direction with Lower and Middle Chazy formations. The Lowville, on the other hand, extends far eastward over the top of

the highest of the Blount formations. There can be, therefore, no question concerning the post-Middle Chazyan and pre-Mohawkian age of the *Telephus*-bearing beds of the Blount group whose relations to formations with similar fossils in southeastern Canada and Europe we are seeking to establish.

Blount faunas differ from similar faunas elsewhere.—The formations of the Blount group being confined in the Appalachian Valley to troughs with sediments of this age pinching out not only to the west but also in northward direction before reaching the southern boundary of Maryland, there is, as already mentioned, no direct connection between them and Mystic in the southwestern corner of Quebec Province, where highly fossiliferous boulders of a particular kind contain *Telephus mysticensis* as one of nearly a hundred mostly undescribed species of the Atlantic fauna of its time. Of these many and varied kinds of fossils none seems strictly identifiable with any of their congeners in Blount formations to the south; and a considerable percentage of the Mystic boulder fauna has no close relatives in Virginia, Tennessee, or Alabama. A few of the brachiopods, especially the species of *Strophomena*? and *Sowerbyella*, which always are difficult to classify, may on final comparison with Whitesburg limestone species prove insufficiently marked by peculiarities to warrant their separation under distinct names. A few of the trilobites also are closely allied to southern Appalachian species, and others are very near or the same as Newfoundland species. In fact Raymond²⁵ indentified some of them with both their southern and Newfoundland allies. Provisionally, I am willing to accept Raymond's judgment regarding most of the latter instances, but in the other cases, after making direct comparisons of Mystic and Newfoundland specimens with their nearest southern relatives, I must question the validity of his opinion. The observed differences, at least as regards the trilobites, seem in every case as great as those which distinguish the American species from their European allies and which in every case he regarded as demanding specific recognition.

Reason for observed difference in faunas.—Now, however similar in general aspect these northern and southern Appalachian faunas may be, why do they contain so few specific identities? I think it is because the beds in which they occur are not strictly of the same ages. In other words, those in the St. Lawrence trough were deposited at times when that part of the geosyncline sank beneath sea level and when its southern part stood above that level. This is not a new and unheard-of conception but merely a new application of views thoroughly discussed and abundantly illustrated by examples

²⁵ Raymond, P. E., Mus. Comp. Zool. Bull., vol. 67, No. 1, 1925.

nearly 20 years ago in my "Revision of the Paleozoic System"²⁶ under the general designation of continental and local "tilting" and "warping." Much was known even then about the north-south and east-west tilting of the only slightly deformed interior area of the continent, but we learn of new instances almost every year. We knew something also of the similar movements in the Appalachian region, but in this much less stable geosynclinal region the new applications of the theory have accumulated faster than we can adequately assimilate and adapt them to the general scheme. A recently published paper by Butts²⁷ gives a fair but incomplete statement of the present status of Appalachian Valley stratigraphy and of the frequent warping and tilting and consequent shifting of land and water areas to which this region was subjected during most of the Paleozoic periods.

Time required to effect observed modifications of faunas now available.—If my conception of the age relations of those formations in the southern and northeastern thirds of the Appalachian geosyncline and, on the other side of the Atlantic, in Scotland, Norway, Sweden, and Bohemia that contain fossil remains of the Ordovician middle Atlantic faunal realm is correct it obviously greatly expands our previous estimate of the aggregate volume of the marine sediments of this period and also of the time required to deposit them. However, even this expansion fails to cover all the missing links of the whole span of time involved, for it does not take into account the probable inaccessibly recorded but logically inferable intervals between the alternating and very slowly effected north-south and east-west tiltings during which the waters of the Atlantic were confined to the oceanic basin between the continents. At those times the continents were too completely emerged to permit marine deposition in the surficial troughs and basins that at other times suffered Atlantic invasion and sedimentation. Under my conception these additional times are required to produce the structural modifications that distinguish the successively evolved stages or "species" that are preserved in the accessible stratigraphic record which, of course, is everywhere more or less fragmentary. Natural evolution, as it seems to me, was always an exceedingly slow process. Supposed or suggested fossil instances of saltatory changes usually prove to have been initiated long before. As a rule the production of the results that are being gradually uncovered by paleontological investigations required more and ever more time than was granted by preceding interpreters of geologic history. Thanks to the physicists and chemists all the time we may require seems now available.

²⁶ Geol. Soc. America Bull., vol. 22, p. 291-680, 1911.

²⁷ Butts, Charles, Variations in Appalachian stratigraphy, Wash. Acad. Sci. Journ., vol. 18, No. 13, pp. 357-380.

ORIGIN AND AGES OF POST-BLOUNT FAUNAS IN NORTH AMERICA
AND EUROPE

Post-Blount formations in America.—It is a well established fact that the east Tennessee part of the Appalachian Valley tract contains no Ordovician deposits with fossils of either the middle or north Atlantic realms that are younger than the Ottosee. Those that succeed the Ottosee here are all extensions of Ohio, Kentucky, and central Tennessee formations with faunas that invaded from the south. But south of Tennessee, in the Cahaba Valley, in Alabama,²⁸ there is a limestone formation, the Little Oak, with a maximum thickness of at least 500 feet, that pinches out in southward direction near Siluria and also in a northerly direction not far beyond Odenville. Near Siluria its thinned southern edge rests on the similarly attenuated extremity of the Athens, but greater thicknesses of both occur in the belt between Shelby and Talladega Springs. At and to the north of Pelham the Little Oak rests on the Lenoir, and over most of its outcrop its top is in contact with Devonian or Mississippian deposits.

The Little Oak fauna, even considering only its generic character, has little in common with any of the Blount faunas except that of the Holston. But it does exhibit a general and in part close resemblance to the Lenoir fauna and through that with the Middle Chazyan fauna in the Champlain Valley.

South of Harrisburg, Pa., and on through Maryland into Virginia, as far at least as Lexington, there is another limestone formation, named from Chambersburg, Pa., that contains a number of faunules that comprise a considerable percentage of species whose relatives are known elsewhere in America mainly or only in the Little Oak, Ottosee, and Lenoir formations. In southern Pennsylvania the Chambersburg rests on the Lowville, which fixes its age as younger than Lower Black River. But at Lexington, Va., beds that are unquestionably a largely traced southward extension of it rest on the limestone facies of the Athens. At both places—also at Strasburg and other localities in northern Virginia and in Maryland—the Chambersburg is followed by Martinsburg shale which begins with the shaly facies of the Lower Trenton. Locally, however, as at Chambersburg, a few feet of shaly limestone, with recurrent middle Atlantic trilobites, intervene.

We have then two post-Blount formations in the Appalachian Valley—one under the Lowville, the other over it—the faunas of which agree in general aspect and in containing at least a few generic types that are believed to be indigenes of the middle Atlantic realm whose purer Ordovician fauna is so well represented in the *Telephus*-bear-

²⁸ See Butts, Charles, *Geology of Alabama*, p. 112, 1926.

ing formations in eastern North America and Europe. But the greater part of both of these faunas is so much more like that of the Lenoir and those of the Lower and Middle Chazy of the Champlain and St. Lawrence valleys that common origin for all of them seems highly probable. But where the bulk of these Middle Chazyan, Little Oak, and Chambersburg faunas originated and by what paths they reached Pennsylvania, Virginia, and Alabama can as yet be explained only by conjecture. Some of the Champlain Chazy species suggest a northern origin, though hardly Arctic, and it may be that they migrated from there by way of the Champlain Valley to the west side of the middle Atlantic basin. Or they may have gotten to inland troughs that are now buried beneath the Coastal Plain south of New York in which they attained and for some time maintained a foothold. The available evidence suggests further that the Chambersburg invasion of the Appalachian Valley came from these more eastern, probably Piedmont and subcoastal plain troughs.

Origin of Trenton and late Black River faunas.—In this connection I wish to call attention also to the Trenton faunas of Ontario, New York, New Jersey and Pennsylvania, and to make the general statement that all but one of these faunas is very different from those of the corresponding Trenton group of formations in Tennessee and Kentucky. Excepting the crinoid and cystid fauna that is held in common by the first or Curdsville limestone formation of the Trenton group in Kentucky and the Hull limestone, which is the second of the Trenton formations in Ontario, the Trenton faunas in Kentucky and Tennessee comprise many clearly indicated progenitors of the succeeding Cincinnati faunas in the same States and like these doubtless invaded the continent from the south. On the contrary, the New York and Ontario Trenton faunas—which not only began their epicontinental record earlier (that is, with the Rockland), but extended their geographical range from Ontario westward to Minnesota and from there southward to the flanks of the Arbuckle Mountains in Oklahoma—these must have invaded the continent from the northeast or north. And an essentially similar conclusion is forced on us regarding the origin of the late Black River Decorah faunas that underlie the Trenton formations in the Mississippi Valley and Ontario. The northern origin of the Decorah faunas is inferred and reasonably proved by the total absence south of central Kentucky of beds that, if present, doubtless would contain them. On the other hand, they are present in most if not all of the exposures of rocks of similar age to the north in Canada. Still more convincing is the fact that comparison of Decorah and early Trenton (Prosser) faunas in the Upper Mississippi Valley with Baltic Ordovician faunas discloses many generic similarities, and particularly among

the Bryozoa,²⁹ a considerable number of specific identities. In view of these otherwise inexplicable facts I see no way to escape the conviction that these Baltic and American faunas originated in and at opportune times migrated from the same oceanic basin; and that basin must have been in either the Arctic or the North Atlantic Sea.

Another point to be brought out is the genetic connection between these Decorah and New York-Ontario Trenton faunas, on the one hand, and the already discussed and mostly older Chambersburg, Little Oak, Ottosee, Holston, and Lenoir faunas of the southern Appalachian region and of the Chazy in the Champlain Valley, on the other. Whatever the modifications and special peculiarities that pertain to and enable us to recognize and distinguish each of these faunas from the others there still remain many genetic threads that are common to them all and indicative of a more or less strongly manifested common source.

But the depositional data pertaining to this hypothetical North Atlantic faunal province are as yet too insufficiently known to be presented as anything better than more or less vague clues to an interesting chapter in the history of Ordovician oscillations and marine faunal migrations. Accordingly, my confidence in the foregoing facts and suggested inferences goes no further than the strong belief that a distinct marine faunal province existed in the North Atlantic region during a considerable part of Paleozoic time. Also that the Champlain Chazy, the Little Oak of Alabama, the Chambersburg of Pennsylvania, Maryland, and Virginia, the Lenoir and parts of the Blount group of Tennessee, Alabama, and Virginia, the eastern and Upper Mississippi Valley Decorah and Trenton formations, the deposits in the Baltic province, and the typical Stinchar of southwestern Scotland all participated in its history.

POST-CHAZYAN—PROBABLY EARLY SILURIAN—FORMATIONS IN EUROPE

Generalized comments on the Ordovician-Silurian boundary.—A problem in stratigraphic correlation on which opinions differ very greatly concerns the proper classification of such European formations as the Drummuck in the Girvan District in southwestern Scotland,³⁰ the Keisley limestone in northwestern England, the Leptaena limestone in Sweden, and the Lyckholm and Borkholm formations in Estonia. Reed identifies some of the Drummuck trilobites with Keisley species and some of the same and other species of the Keisley with characteristic members of the Leptaena limestone fauna; and there is general agreement among British and Scandinavian geolo-

²⁹ Bassler, R. S., Early Paleozoic Bryozoa of the Baltic Provinces: U. S. Nat. Mus. Bull. 77, 1911.

³⁰ See also notes on the "Craighead" limestone, p. 84.

gists in correlating the mentioned formations with each other and also, though somewhat more loosely, with the Lyckholm and Borkholm of the Baltic region. They agree, further, in referring them all to the upper part of the Ordovician system. Perhaps, and I may even say probably, they are right in holding to this opinion so long as the base of the Llandovery in Wales, the Rastritesskiffer in Sweden, and the Addifir in Estonia are insisted on as marking the base of the succeeding system. But is their apparently still uncompromising attitude on this question warranted by the changing needs of a growing science? I have thought and still think it is not.

On various occasions, but especially in my most recent paper on the Ordovician-Silurian boundary,³¹ I have cited and discussed many facts that show that this is not the most natural nor the most widely recognizable boundary nor the one that marks the beginning of physical conditions that distinguish the new period and sets it apart from the preceding. Besides, the contact of the Llandovery with the Bala and Caradoc, which Lapworth in 1879 designated as the boundary between his newly proposed Ordovician and the restricted Silurian system of Murchison, does not correspond to the boundary between the Champlain and Ontario divisions of the New York system that were proposed by Emmons and his associates on the New York Survey in 1842 and which since then have been generally abandoned in favor of the no better defined and, in their present significance, much younger British terms. I am not a sufficiently strict adherent to the law of priority to object to this usurpation of terms, but I do object to the abandonment of those features of the original New York classification that in my opinion give a better and more natural classification of the concerned parts of geological history.

The advantage of the original definition of the term Ontario (or Ontarian as Dana amended it in 1890) over the definition of the restricted Silurian system that now prevails rather generally in Europe lies in the fact that both its lower and upper boundaries as delimited by Emmons in 1842 are more consistent with nature's definition³² of the period to which it was applied than is Lapworth's redefinition of the term Silurian that has been adopted by most American geologists since 1879 without adequate investigation of its fitness as a major term in the classification of American formations. Emmons defined the "Ontario group" as overlying the Champlain group and underlying the Helderberg series and as including the Manlius at the top and the Medina sandstone at the base. This definition accords precisely with the system of rocks in America for

³¹ Relative values of criteria used in drawing the Ordovician-Silurian boundary, *Geol. Soc. America Bull.*, vol. 37, pp. 279-348, 1926.

³² Ulrich, E. O., *idem*, p. 326, 1926.

which I have used the British term Silurian since 1910. But it does not agree in either its base or its top with Lapworth's Silurian system. As defined by him the Silurian system in Britain comprises the "strata comprehended between the base of the *Old Red sandstone* (Devonian system) and that of the *Lower Llandovery*," which differs considerably from the "Ontario group" of Emmons, the original limits of which were retained without modification when most of us discarded its American designation and adopted Silurian in its place. Lapworth's definition includes beds corresponding to our Helderbergian series, which all American geologists now refer to the base of the Devonian; and it excludes and refers to the Ordovician all beds in Great Britain that are older than the base of our Clinton, whereas in American practice without exception the Silurian includes the whole or at least the upper half of the underlying Medinan series.

The differences between the British and American practice in drawing the top and bottom limits of the Silurian arise in part from differences in methods. The former inclines, at least in these cases, to the practice of beginning a system at a stratigraphic break that immediately underlies the first well-established change from the dominant character of the fauna of the preceding period to that of the succeeding period. The latter inclines rather to the practice of beginning the new system with the first diastrophically well marked introduction of the new fauna. But, for obvious reasons—particularly as regards difference or likeness in source of the compared faunas and the greatly varying dates at which marine deposition of a given period began or ceased in the numerous epicontinental basins—the degree of difference in the general aspect of the faunas in beds that are contiguous yet of different periods depends very largely on only locally operating factors. Thus, if the faunas of such adjoining beds invaded from the same oceanic realm the younger of the two is likely to comprise a strongly dominant part that is made up of direct descendents of the older fauna; if they invaded from different realms then the difference between the two is much greater and often complete.

Even in different parts of the same continental province the first deposit of a given period may be shown by its fossils to be either much younger or older than is the first of the period in other parts. In some places only the lower series of a system may be represented, in another only its middle, and this may then be followed by the closing stage. Again, in some places only the closing series is represented whereas in other places beds of the closing series are in contact with deposits of the lowest series. Finally, there are a few places where fuller sequences with a thick middle series are found.

All these varying sequences of the deposits of a given period—and the Silurian as developed in southeastern North America is no exception—may occur in a distance of 100 to 200 miles. It makes a lot of difference, therefore, in the final systemic classification of formational units where the type section of a system, series, or group may be. And in the case of the Silurian, provided world-wide application of divisions of the stratigraphic column of its grade is contemplated, I see no reasonable ground for insisting that the system must be limited below by the base of the Llandovery. As we know from the work of Jones and others; and as I know from personal observations in the concerned areas, the base of the Llandovery in Wales and Shropshire is unconformable by overlap so that the stratigraphic significance of the hiatus between it and the underlying Ordovician formation varies from place to place. Doubtless if this hiatus could be pursued to its minimum in Britain the unconformity would pass beneath beds that are not present in Wales and Shropshire and which, despite their inherited Ordovician faunal types, would be more naturally classified as early Silurian than late Ordovician.

Age of the Keisley limestone and other European formations.—In 1926,³³ in discussing the persistence of important Ordovician generic types of the Middle Atlantic fauna to apparently early Silurian time in certain European formations, I pointed out that the Drummuck of Scotland and the Keisley of England, also their generally accepted Scandinavian and Baltic equivalents, all contain the first appearances in their respective countries of genera that occur in North America only *above* Richmond in beds that are universally admitted to be of Silurian age. A composite list of the better known of these genera includes, of brachiopods, *Atrypa*, *Atrypina*, *Bilobites*, *Chonetes*, *Dictyonella*, *Meristella*, *Mimulus* (or *Streptis*), *Rhipidodomella*, *Schuchertella*, *Stropheodonta*, *Strophonella*, *Whitfieldella*, and varieties of *Dalmanella elegantula* and *Rhynchotrete cuneata*; and of trilobites, *Cheirurus* s. s., *Deiophon*, *Dicranognmus*, *Dicranopeltis*, *Lichas* s. s., *Arctinurus*, *Staurocephalus*, and *Trochurus*. In my opinion, none of these genera originated in the middle Atlantic realm. They are migrants from the southern Atlantic basin or from some other marine breeding ground that lay to the south of the present Gulf of Mexico and which supplied the greater part of most of the Silurian faunas that invaded America through the Mississippi embayment.

A fact of considerable importance in this connection—important because it supplements and greatly strengthens the previously available evidence on which I based my view as to the time when these

³³ Geol. Soc. America Bull., vol. 37, p. 322.

southern genera appeared in the temperate zone of the northern hemisphere—was noted in looking over Twenhofel's recently published work on the Geology of Anticosti Island. In this report Twenhofel illustrates and very briefly describes four *Lichadidæ*, three of them new and all referred to the genus *Amphilichas*. The oldest of these, *A. borealis*, new species, founded on a cranidium collected from the upper half of the English Head formation, is a normal *Amphilichas* and much closer to other American Richmond species than to the Swedish *A. dalecarlicus* with which Twenhofel compares it. However, the other three Anticosti species belong to two of the genera above listed as Silurian migrants from the south. One, *A. shallopensis* Twenhofel, from zone 9 of the Jupiter River formation, is a typical *Lichas*; the other two—*A. canadensis* (Billings), from the lower half of the Jupiter River, and *A. arenaceus* Twenhofel, from the top bed of the underlying Gun River formation—are based on such characteristic pygidia that I refer them without hesitation to *Arctinurus*. The presence of species of *Lichas* s.s. and *Arctinurus* in Anticosti and their restriction here to zones that all agree are of the age of the Clinton are facts that for three reasons are regarded as of particular significance in the determination of the age relations of the Keisley and related north European deposits to formations of the American Paleozoic sequence. First, because unquestioned Richmond formations (English Head and Vaureal) are succeeded in the Anticosti section by two formations (Ellis Bay and Beesie) that I regard as representing the Upper Medina or Alexandria group of New York and the Mississippi Valley and which in turn are succeeded by the Gun River and Jupiter River formations, which contain the mentioned species of *Lichas* and *Arctinurus* and of which the latter and at least the upper part of the former are undeniably of Lower Clinton age. The second reason is the well-known fact that the faunas of the Clinton part of the Anticosti section exhibit closer relations to British Llandovery and Wenlock faunas than any other Silurian section in North America. The third reason is that in Europe as in America the above listed genera of brachiopods and trilobites that have been set down by British and most European geologists as common to Ordovician and Silurian deposits in their countries attain their best development in Upper Clinton and later Niagaran deposits; and they do not occur at all in America beneath the top of the Medina nor in Britain and Sweden beneath the formations that I claim would be more naturally classified as early Silurian than late Ordovician.

The misunderstandings that have so long beclouded the problem of the proper position of the Ordovician-Silurian boundary have

arisen mainly from the fact that in the Drummuck and Keisley of Britain, the Leptaena limestone of Sweden, and to lesser extent in the Borkholm of Estonia the, as I think, really Silurian species of the above-listed genera of brachiopods and trilobites are associated with a predominating number of direct descendants of preceding stages of the middle Atlantic fauna found in underlying really Ordovician formations in the same countries. Because of the dominance of these persisting, "residual" Ordovician elements—among them even a species of *Telephus*—it is only to be expected that in following the formerly prevailing but now thoroughly discredited method of determining the age of a formation by the relative dominance of generic and specific similarities in compared faunas geologists generally assigned these legitimately debatable formations to the Ordovician. However, in doing so they caused much regrettable confusion in stratigraphic correlation and great but I hope only temporary impairment of the indexical value of more than 30 genera of fossils. In making this statement I do not wish to be understood as implying that the vertical range of these generic types is fixed and chronologically the same the world over and that they did not exist *somewhere* in recognizable form either earlier or to later dates than the information now available indicates. On the contrary, I feel certain that the 30 genera just referred to originated and slowly developed their characteristics in southern marine realms, the Silurian life of which we know now only through the little we can gather from the migrants that reached and left their remains in epicontinental basins of the northern hemisphere.

Silurian age of the Leptaena limestone proved by graptolites.—Facts that give me much satisfaction because they will be accepted generally by European geologists as proving the Silurian age of the Upper *Leptaena* (Kallholn) limestone and its equivalents or near equivalents elsewhere, and also of the underlying Dalmanites shale have recently been brought out by Troedsson and Roswall who found that black shale with Middle Birkhill graptolites are really interbedded with the reefy deposits of the former at Kallholn, Dalarna, Sweden. So much of the battle seems thus to have been won. But why not go a step or two further down in the section and drop the Ordovician-Silurian boundary to some still lower diastrophically marked plane that would more nearly correspond to the naturally defined and very widely recognizable stratigraphic break in the American section? For instance, to the base of the *Staurocephalus* zone; or even to the bottom of the "Trinucleus beds?" The latter, like the Middle Richmond Sylvan shale in Oklahoma, contains a species of *Dicellograptus* that is referred to the British Upper Hartfell *D. complanatus*; and this is not by any means the only fossil

that may be said to suggest that the *Trinucleus* beds are of early Richmond (i. e., post Maysville) age.

Troedsson, in the stratigraphic part of his 1928 report on the Middle and Upper Ordovician faunas of northern Greenland, devotes many pages to the discussion of this problem. But his conclusions, at least in so far as they are concerned with the faunas of the American Richmond and Mohawkian formations, are largely based on erroneous or insufficiently digested data. In consequence the conclusions are usually at least open to question and in most cases definitely negated by more competent modern evidence. Unfortunately most of the latter evidence is as yet unpublished; and it is impossible to settle the questions involved in the proper classification of the Arctic Ordovician and early Silurian formations before the old data have been either substantiated or corrected and carefully studied in the light of the new evidence. Although much of this work has been done considerably more remains to do before I shall feel ready to record final conclusions.

Inadequacy of formerly prevailing methods of correlation.—So long as we depended indiscriminately on predominance of trend of evidence determined by matching entire faunas rather than on precise identification of particular species in both intra- and interprovincial correlations, and so long as we followed Suess in explaining the observed evidences of Paleozoic and later displacements of the strandline as essentially eustatic, there really was but little or no chance to achieve definiteness and verity in details in determining the age relations of disconnected formations, whether their separation is ocean wide or relatively limited. I am referring particularly to formations in regions that as a rule are affected differentially by the slowly but constantly proceeding undulatory movements of the surface of the lithosphere.

The rudiments of these revolutionary ideas entered my mind when, nearly 30 years ago, I noted the rather unsatisfactory results attained in the endeavor to correlate the Ordovician formations in America by data obtained during the course of my paleontological work in Minnesota.³⁴ Casting about for some possibly more definite physical means of checking the fossil evidence the rather obvious relation of the processes of diastrophism to the then new Dutton theory of isostasy seemed to offer a promising field for investigation. Soon this promise gave way to greater and since then constantly growing con-

³⁴ No more conscientious or more thoroughly finished effort to correlate formations by matching entire faunas and also no greater failure to achieve true solutions, particularly as regards the lower faunal horizons, is to be found in geological literature than my 1896 attempt to correlate the Ordovician formations in Minnesota with those in Kentucky, Tennessee, and New York. (See Minnesota Geol. Survey, Final Rept., vol. 3, pt. 2, pp. LXXXIII—CXXII.) What a help some of the ideas here briefly discussed would have been.

fidence in the faunal and stratigraphic criteria of diastrophism, which in my definition of the term includes evidence of any movement of the surface of the earth that occasioned displacement of the marine strandline and resulted in generic modifications of the preceding composition of faunas and floras or in their local extinction or complete replacement by faunas derived from other sources. My confidence has grown constantly also in the consequent paleontological principle that the more or less abrupt introduction of new generic types in epicontinental marine deposits, especially if the new elements were derived from a previously excluded faunal realm, is a far more reliable criterion in fixing stratigraphic boundaries and in determining their taxonomic significance than is the general or composite aspect of the fauna in which these foreign constituents occur. The importance of these invasions of foreign elements—whether they appear but once or repeatedly at intervals in a given section—lies in the probable fact that some diastrophic movement, the results of which included submergence of a previously excluding barrier, had occurred at times shortly preceding their advent.

That my confidence in these views has not been misplaced is proved by the great success that has attended their application in American stratigraphic problems. As they served very well in these it seemed probable that they would serve equally well in the apparently quite similar European cases in question. Accordingly, in the paper on the Ordovician-Silurian boundary already cited I advocated removal of the Drummuck, Keisley, Upper Leptaena, and other north European formations generally regarded as of approximately like age from the lower side of the line to above it. Obviously, it is with considerable interest that I await the reaction of European opinion to my proposal. For two reasons the points mainly at issue are presented here again, though more briefly and viewed from somewhat different angles; first, because the opportunity to say what I hope may be my last word on the subject is at hand; and, second, because the facts mentioned in its discussion have a decided bearing also on my contention respecting the generic persistence of the indigenous life of the middle Atlantic realm—or, indeed, of any of the centers of faunal development and dispersal—which I find to be much greater than anyone believed heretofore. It has been also the most pregnant though perhaps least suspected cause of error and general confusion in correlating formations of different provinces.

General similarity of fossil contents without precisely identified closely drawn species certainly does not establish contemporaneity of the compared deposits. On the contrary, it usually indicates difference in age. Moreover, it is practically impossible to correctly estimate the chronologic significance of such differences except when

discovery of overlaps of concerned formations furnishes the proof of at least a part of its possibly very great importance. No more strikingly illuminating example occurs to me that the slight difference in the faunas of the Lebanon and Lowville limestones which are in contact in central Tennessee but separated in east Tennessee by a maximum of 8,000 to 10,000 feet of limestone and shale deposits with entirely different fossils. To further illustrate the uncertainties that generic matching of fossil faunas may entail I would mention the supposititious but easily conceivable and quite possibly actual contemporaneity of marine deposits with entirely different fossils. Such a case could be explained only after we had learned that one of the faunas had originated in and invaded from, say the Pacific, the other in and from the Atlantic, and that both are directly overlain and underlain—without sign of discontinuity of deposition—by the same pair of formations.

RECENT PROGRESS IN AMERICAN STRATIGRAPHY

Old and new data indicating persistence of indigenous faunas.—The truth of preceding statements regarding the indigenous persistence of faunal assemblages is clearly shown by previously published information concerning the now undisputed recurrences of the Spergen fauna in early, middle, and late Mississippian formations. Interest in this case has been revived and emphasized by two still younger recurrences of the same dwarfed fauna in Pennsylvania formations, the highest only recently discovered by Charles Ryniker in Oklahoma. Apparently these recurring hordes of small fossils are really to be regarded as long persisting and very slowly modifying dwarfed descendants of a far southern Middle Devonian fauna of which normally sized individuals reached New York State already in Hamilton time. Whether this inferred derivation of the diminutive molluscan Spergen fauna is correct or not there certainly is less reason for considering most of its constituents as dwarfed forms of species of the same classes found in intervening Mississippian and Pennsylvanian beds. The latter probably were produced in a nearer breeding ground that supplied, or at least contributed to, most of the Paleozoic faunas that invaded America from the south through the Mississippi embayment. Another alternating sequence of invasions from two distinct faunal centers through the same Lower Mississippi entrance comprises the simulating late Trenton Catheys fauna, the Fairview fauna, and, finally, the early Richmond Arnheim fauna, on the one hand, and the preceding Trenton and intervening Cincinnati faunas on the other. The latter also exhibit a more marked general resemblance to each other than to the immediately succeeding and preceding faunas of the first set. Many other such instances of

more or less widely spaced invasions of but slightly modified stages in the evolution of the life history of a particular marine breeding ground alternating in the same sections with similarly related emanations from another source might be cited. However, those mentioned sufficiently illustrate the general idea I am intending to convey. Besides, some of them—like the notable cases of the Utica and the Maquoketa that concern graptolites and other thin-shelled remains usually found in Ordovician and Silurian deposits of black shale—require too much explaining. Therefore, all I think worth adding is that in all the mentioned cases the alternating changes in the character of the faunas are never complete. Evidently the invasions from the farther source in passing through some part of the nearer source joined the usually smaller contribution of the latter. Then, when the supply from the more distant source was reduced or completely cut off some of its species that had gained a foothold in the nearer source were thus included in its subsequent contributions. It is to be noted further that when these changes occurred the ensuing invasion usually included also a few and sometimes many contributions from other previously excluded sources; and it is these entirely new migrants that constitute the most reliable and the most easily notable of its guide fossils.

Progress in middle western and Cordilleran regions.—Extremely interesting and important stratigraphic results have developed in the course of field and laboratory investigations of the character and geographic distribution of faunas and formations in Oklahoma. These relate particularly to demonstrations of early and middle Paleozoic surface undulations and consequent shiftings of the strandline on the flanks of the Arbuckle and Wichita uplifts in the south central part of the State. Comparison of numerous cross-sections shows that the sequence of formations on their flanks varies greatly and rapidly from place to place. And the faunal evidence, doing its part in the elucidation of the geological history of North America, shows that these areas suffered alternating invasions from the Pacific, Arctic, Atlantic, and southern sides of the continent during each of the Cambrian, Ozarkian, and Ordovician periods. Much of the doubt and misapprehension that has prevailed in Oklahoma stratigraphy, especially as regards relations to deposits in the adjoining States of Missouri and Arkansas, is being explained in orderly fashion by these discoveries. Each of the pre-Mississippian formations of preceding classifications is being divided on faunal and diastrophic criteria into two to six clearly distinguishable formations; and the locally extremely varying great sequence of limestone deposits that in Taff's classification is called Arbuckle limestone is split up into one Cambrian, six Ozarkian, and three

Canadian formations. In short, we are prepared to give an altogether new and very different account of Oklahoma stratigraphy that moreover throws much new light on the interpretation of geological events in other parts of the continent.

As details regarding the results of these studies will probably be published in the near future their further anticipation here seems undesirable. What has been said sufficiently indicates the progress that is being made in working out the broader aspects of the Paleozoic history of the middle part of the Mississippi Valley region. Great progress is being made also in the already much better known Upper Mississippi Valley region. The results of these investigations, which comprise much more detailed information regarding the paleontology of especially the Cambrian, Ozarkian, and Canadian deposits than is now available in published form, is also being prepared in collaboration with others for early publication. Nor are the results of continued investigations in the Cordilleran province that were begun by Walcott and inherited by Dr. Charles E. Resser and myself falling short of expectations. In fact, the stratigraphic and extremely abundant faunal data from all of these regions are being studied concurrently.

Finally, as regards the Appalachian region, the years of painstaking labor bestowed on it by Dr. Charles Butts are correcting, supplementing, and gradually filling in the details of work begun by me nearly 30 years ago and partly published in 1911. Hundreds of pages filled with notes on redefinitions of formations and new positions assigned to them in the correlation tables and detailed descriptions of sections and faunal lists, which had been written and submitted with the discussion of principles and criteria of stratigraphic correlation that was then published under the title *Revision of the Paleozoic Systems*, remain unpublished to this day. With the help of Dr. R. S. Bassler, who assisted me in the field during parts of the ten years mainly devoted to stratigraphic investigations in the Appalachian Valley, much of this neglected manuscript will be revised to meet present-day requirements and again submitted with subsequent observations for publication. In the meantime results of Doctor Butts' investigations in the southern end of the valley have been published by the United States Geological Survey in the *Birmingham Folio* and more fully in the volume published by the State on the *Geology of Alabama* (1922). During the past two years he has been engaged on the Virginia part of the valley. His work here is disclosing an astounding amount and variety of highly interesting and important details as regards the distribution of formational units, stratigraphic overlaps, and consequent local variations in the sequence of beds and the geologic structure of the area.

In a mental review of the accomplishments in American stratigraphy during the past 30 years the feature that impressed me more than any other is that in this short time the aggregate thickness of the Paleozoic rocks in America alone has been shown to be nearly three times as great as we thought it in 1898. Many thick formations that only 20 years ago were regarded as contemporaneous deposits have one after another proved to be of distinct ages; and when one had been traced over or under the other the contact between them still was broken; and when this contact had been traced to another supposed equivalent the latter was found to wedge into the break which opened often widely to receive it. However much our efforts to fill the gaps have been rewarded we seem to succeed only in dividing them into smaller breaks. And so, especially if views discussed on preceding pages are not wholly visionary, I realize perhaps more than any other that the task of building up the world sequence of epicontinental marine deposits is far from completed.

European geologists have not kept pace with us in recognizing the extremely oscillatory nature of marine invasions and ensuing deposition in epicontinental basins, nor have they discriminated and correlated their Paleozoic formations in accord with anything like our conception of small shallow seas that, in responding to frequent surface warpings, were largely or entirely withdrawn or shifted from one negative area to another. The older generation of geologists are not expected to take very kindly to such unsettling views, but the younger ones, in whose hands the future of the science lies, will, I am sure, at least consider and try them out, because they promise a rich reward.

At present, detailed interprovincial stratigraphic correlations, referring particularly to lower and middle Paleozoic marine formations on the two sides of the Atlantic, are shrouded in uncertainties. These are occasioned partly by neglect of other than fossil testimony but mainly by lack of strictly and specifically comparable faunal evidence. When the generic aspects of such evidence seemed to point toward a reasonable conclusion the hope of success, at least as regards my own efforts, has been nearly always negatived by associated things of contrary trend. I must, therefore, frankly confess that I do not know how certain British formations and the usually smaller Scandinavian and Baltic units will finally fit into the greater American stratigraphic record, or how they will assist in the perhaps impossible task of completing the geological time scale of the world. I fear, too, that my present effort has succeeded rather more in complicating the issues than in simplifying and deciding them. Let us hope that it may prove the darkness that precedes the dawn. Time will tell, for it will bring the fuller and truer knowledge of the fossil faunas

column is taken from the Mississippi and Ohio Valleys and the Ordovician part from the southern Appalachian Valley and central Tennessee except the Buffalo River series, which is best developed in northern Arkansas. As will be observed, only the Chazyan part of the column is divided into units of formational rank, this being the part that is mainly concerned with questions discussed in this paper. Besides, and however detailed the correlations of American Ordovician and Silurian formations may be, we can as yet do no better in correlating European formations of these periods than to suggest more or less indefinitely located positions for them in one or another of our series or groups.

Though this column is called a time scale it should not be assumed that even its Ordovician part accounts for all of the time included in this period. In fact it accounts only for those subordinate parts of the accessible depositional record that was laid down in American epicontinental basins; and of these only those whose sequential relations have been established. As most if not all of the named minor units of the scale are separated from each other by stratigraphic breaks of undetermined time significance it follows that these depositionally unrecorded intervals, at least, are not accounted for. Doubtless some of these intervals are represented, probably only in part, by deposits in other areas of the North American Continent, but these could not be used in constructing the scale because their relations to those found in the southern Appalachian, Ohio, and Mississippi Valleys are insufficiently understood; and we know even less about the correlation of the European and American Ordovician deposits. Finally, as suggested previously (p. 54), there may have been times when the continents on both sides of the Atlantic were so elevated above sea level that the basins in which Ordovician marine deposits are now accessible were completely drained. Obviously such times also are not accounted for. It follows, then, the "generalized time scale" of the chart is incomplete to these several extents and pretends to be nothing more than a temporary standard for comparison.

Perhaps I should call attention also to the fact that the correlations with formations in European countries differ considerably from those given in a similar table published by me only three years ago.³⁵ However, the changes occur mainly in the lower two-thirds of what I think should be included in the Ordovician system, which, as many know, I define differently from the original and even yet prevailing conception of that term. Briefly stated, my definition of the Ordovician system is based primarily on diastrophic criteria that in my

³⁵ Relative values of criteria used in drawing the Ordovician-Silurian boundary: *Geol. Soc. America Bull.*, vol. 37, p. 329, 1926.

opinion demand elimination of formations from both the top and the base of this system as originally defined by Lapworth. The evidence on which these views are based, particularly those facts that concern the upper boundary of the system, are briefly discussed above and much more fully in the just cited Ordovician-Silurian boundary paper published in 1926. The evidence relating to the lower boundary was already rather thoroughly pointed out in my "Revision of the Paleozoic Systems" published in 1911, but some of it will again be presented with local details and in generally amplified form in a work on the Paleozoic formations in Oklahoma due to appear before the close of the present year.

Generalized comments on other columns of table.—Regarding the changes in correlating European and American formations that continued study of the extremely difficult problems in the past three years has indicated, I make no apologies. The innovations are presented as suggestions and not as final conclusions. They are based on theoretical considerations and reasonable inferences and probabilities that are not yet susceptible of satisfactory proof—and may never be. Still, they seem as well worth trying out as other not very dissimilar suggestions were that have been presented in the past twenty years and whose merits have in the meantime been fully established.

The probable bearing of the postulated differential character and slowness of the vertical movements of the surface of the earth on the correlation of formations in the more or less widely separated geological provinces covered by the table is indicated by the intermediate placing of many of the names of the formations in the several columns. However, I am not at all certain that the European and even some of the North American formations actually belong in the positions assigned to them in the chart. Any of these may belong a notch or two higher or lower in the time scale than is indicated by the present status and probable trend of the organic and physical evidence studied to date. But I do feel satisfied that the tentative arrangement presented in the chart is a nearer approximation to the facts in the several cases than any previous effort has attained.

Of extreme and commanding importance in working out the sequence of events and the great length of time involved in the geologic history of the Lower Paleozoic ages is the indisputable fact that so far as known the least incomplete depositional record of these ages occurs in America. I venture to say further that, so far as the stratigraphic correlation of the marine deposits of these ages in the several largely supplementing provinces in North America is concerned, the record of the frequently shifting Paleozoic epicontinental seas is also better understood than is the more epitomized and on the whole much less completely developed record found in European

countries. Let me not be misunderstood here. I have no wish to deny that the local developments of the fossil faunas in Bohemia, the Baltic region, Sweden, Norway, and, perhaps in less degree, also in Great Britain have been more thoroughly exploited and the results of their study published than in America. This admission applies particularly to the often extremely fossiliferous pre-Cincinnati formations in the Appalachian Valley, central Kentucky, middle Tennessee, Missouri, Arkansas, and Oklahoma, but it should not be interpreted as implying that we have neglected to collect and study these faunas. We have failed only in this, that publication of the results has lagged far behind our information regarding their character and stratigraphic significance.

Having the maximum development of lower and middle Paleozoic marine deposits and also a more detailed conception of the sequence of geologic events recorded in and by them it seems not only natural but also desirable that the American record should be the standard for world-wide comparison. If this were conceded then even very elementary comparisons of classical north European Eopaleozoic sections with American sections of the same era would convince the observer that the composite European sequence is not only inferior in completeness but also that the stratigraphic hiatuses in it are of greater chronologic significance than has been recognized by those most familiar with the fossil contents of the concerned deposits.

EXPLANATORY NOTES ON THE FORMATIONS IN THE SEVERAL COLUMNS

Oklahoma.—This sequence of formations is found on the flanks of the Arbuckle and Wichita Mountains in the south-central part of the State. At the base and resting on pre-Cambrian granite and porphyry are the two Upper Cambrian formations. Over these comes the great series of dolomitic and pure limestones to which Taff applied the term Arbuckle limestone, but which is subdivided into a number of formations in a work nearing completion. The lower part is divided into six oscillating Ozarkian formations, two of which are confined to the Arbuckle area, two to the Wichita area, and two are datum planes common to both. The greater upper part of the Arbuckle is of Canadian age and divided into three formations, the limestones of the Lower and Middle Canadian being provisionally united in one and the lithologically more varied beds of Upper Canadian age into two.

The succeeding Simpson of Taff's classification comprises seven variously distributed and interfingering formations. Of these only the topmost (Bromide) has been previously named. The others are newly named as in the table. Each begins with a sandstone of

from a few feet to more than 100 feet in thickness and is distinguished from the others by a complete change in the character and in most cases also in the derivation of its fauna. The first (Joins) and second (Oil Creek) derived their faunas from the west, whereas the third (McLish) contains species of the Appalachian Lenoir fauna, which therefore are regarded as indicating an invasion from the east at this time. The fourth (Falls) contains species found elsewhere in America only in Nevada and western Texas, which is interpreted as showing that the sources of the invasion was again in the Pacific. The fauna of the fifth formation (Tulip Creek) compares closely only with Stones River faunas of Tennessee, and is therefore held to be an Oklahoma recurrence of that southern fauna during Blount time that did not reach central Tennessee. The fauna of the sixth (Criner) formation again differs radically from that of the next underlying formation. Genetically comparable fossils occur only to the east in Blount and Chambersburg formations. Finally, the faunules of the succeeding Bromide formation are essentially the same as those found in the Black River and early Trenton formations in Iowa and Minnesota, whose northern origin has long been recognized.

The position of the succeeding Viola limestone in the time scale can not as yet be fixed with precision. We know, however, that it follows the Trenton, so that it must fall somewhere in the Cincinnati or into the hiatus that everywhere separates that series from the Richmond. Its graptolites compare rather well with the Upper Hartfell of Britain, and its trilobites, among which species of *Cryptolithus* predominate, agree better with British Caradoc forms than with any other trilobite fauna known. The Tyner and Sylvan are early Silurian and clearly correspond to parts of the Maquoketa of Iowa. Above these come thin limestones of Upper Medinan and Clinton ages that are better developed in eastern Missouri and northern Arkansas.

Mississippi Valley.—At the base of this column the Ozarkian and Canadian depositional record between the top of the Upper Cambrian and the base of the Buffalo River series in Missouri is broadly indicated on the left side and the inferior record of the same systems in Wisconsin on the right side. Throughout the valley north of Tennessee limestone of Black River age rests on the Buffalo River series. Evidently, about 10,000 feet of deposits—more than half of this thickness consisting of limestone—that occur in east Tennessee and other parts of the Appalachian Valley are wanting in States bordering the Mississippi. Generalized, but in most cases very detailed correlations of the formations of the Mohawkian series in this column with those in Oklahoma, Kentucky, Tennessee, or

New York are too well established to require further comment here. But the case of the succeeding Galena dolomite is quite different. The more I study this formation the less I am satisfied with the reputed Trenton age of its typical parts. Provisionally, and mainly to emphasize my doubts regarding its precise age, I have moved it up in the scale opposite the Cincinnati. At present it seems that the dolomite in the vicinity of Dubuque, Iowa, is certainly a younger formation than the Kimmswick limestone of Missouri, with which it has been correlated by other geologists; and some of the beds that have been assigned to the Galena in Wisconsin are older than Trenton, whereas others are younger than the Maysville of Ohio. A special paper needs to be written about the Galena.

Ohio Valley.—No deposits of the Buffalo River series occur in Tennessee, but in Kentucky a calcareous phase of one of its sandstones is found in deep wells as far south, at least, as Lexington. Over it are at least three of the limestone formations that make up the Stones River group in central Tennessee. This group attains greater thickness in the western third of the Appalachian Valley, but pinches out completely and rapidly to the west of the Cincinnati anticline. The absence of the southern Appalachian Mosheim limestone in both Kentucky and central Tennessee is a notable feature of this column. Formerly the Mosheim was believed to be included in, or to underlie, the horizon of the Murfreesboro limestone. However, in August of 1928 Doctor Butts and I studied a completely exposed section in the eastern part of Lee County, Va., in which both formations occur in typical development and in which the Mosheim *overlies* the Murfreesboro. In the next Ordovician belt to the southeast the Murfreesboro is absent and the Mosheim as usual in contact with the eroded top of the Canadian system.

In Kentucky and Middle Tennessee the Lowville limestone of the Black River group is in contact with the top of the Stones River, the great Blount group and also the succeeding Little Oak limestone of east Tennessee and Alabama being absent. The Black River also lacks some hundreds of feet of limestone beds that are present in the section of Mulberry Valley north of Sneedville, Tenn. The Trenton, however, is more fully represented, though its beds and fossils are very different from the beds and fossils of similar age in New York and Pennsylvania. The Prosser of Minnesota, being closely akin to the New York Trenton, differs in like manner from the Trenton of Kentucky and Tennessee. Evidently the New York-Minnesota Trenton faunas invaded the continent from a different source than that which supplied the life of Trenton formations in Kentucky and Tennessee. As these northern and southern facies of the Trenton have not yet been found interfingering or mingling

with each other we can not say what, if any, differences in age the observed differences in their respective faunal contents may indicate.

In essentials the Cincinnati series is much the same on the Cincinnati axis as in New York. However, both regions exhibit faunal and lithologic details that distinguish the sequence in one from that of the other. Most of these differences have been discussed by Ruedemann,³⁶ but to appreciate their full significance many as yet unpublished facts that have been disclosed by study of this part of the column in Pennsylvania and Virginia must be taken into consideration. Obviously the subject is too intricate to warrant anything more than its mere mention on this occasion. The case is similar with respect to the Medinan formations concerning which so much wholly unpublished, or only partly published, information is in hand that adequate discussion of its problems constitutes the material of another of my uncompleted papers.

Southern and middle Appalachian region.—It would require at least 10 columns to present in correct and readily understandable manner the variations in sequence of the Ozarkian, Canadian, Ordovician, and later formations that are known to occur in the Appalachian Valley region from central Pennsylvania to central Alabama. The sections would be in sets of twos and threes taken at intervals across the strike of the valley troughs and two, or better three, sets taken at points along the strike. But, however, interesting and illuminating such a series of columns would be, my present purpose is particularly concerned only with the oscillations in the valley troughs that are indicated by the distribution of the Chazyan deposits and faunas. Accordingly this column may be characterized as a rather unsatisfactory composite presentation of the frequently varying sequence of formations in the southern and middle stretches of the Appalachian geosyncline.

Absence of the Buffalo River series emphasizes the chronologic significance of the break between the Ordovician and Canadian systems. As a rule the value of this hiatus in the valley south of Staunton, Va., is further increased by absence of the Murfreesboro which, as above mentioned, has been observed to wedge in from the west in the eastern part of Lee County, Va. Elsewhere in the valley Ordovician sedimentation usually begins with greatly varying thicknesses of Mosheim limestone, but there are many places in Virginia, Tennessee, and Alabama at which not only the Mosheim but also most or all of the Lenoir and the Holton are missing, so that the Athens shale is in contact with the Canadian.

The facts just mentioned and the many similar variations that occur at the contact between the Canadian and Ordovician wherever

³⁶Ruedemann, Rudolf, The Utica and Lorraine formations of New York, New York State Mus. Bull. No. 258, 1925.

rocks of these ages were deposited in North America constitute the physical part of the evidence on which I base my claim that this is one of the most important breaks in the Paleozoic column. And the organic part of the evidence is no less impressive. The stratigraphic significance of the gap between the two systems is narrowed to its observed minimum in Lawrence County, Ark., where it is reduced (1) by the insertion of two formations at the top of the Canadian that are not present elsewhere in the Ozark region and (2) by the downward expansion of the Buffalo River series which attains its maximum development in Newton County about 100 miles west of Lawrence County. To the north and west of Newton County the chronologic significance of the gap then increases rapidly to places at which the Powell or even the Cotter—respectively, the third and fourth formations beneath the top of the Upper Canadian—is directly succeeded by deposits of Mississippian age. Surely, conclusions based on such data deserve respect and more general acceptance.

Proceeding with the explanatory notes on the middle and southern Appalachian column, the conventions employed indicate that the Murfreesboro, Pierce, and Lebanon formations lap out eastwardly and the Mosheim pinches out in the opposite direction. The Lenoir, however, seems to extend completely across the valley in southwestern Virginia and is supposed to have attained weak connection with the Ridley in central Tennessee and Kentucky. But no such alternation of Atlantic and southern invasions of the Appalachian geosyncline is indicated by the formations of the Blount group, all of which are confined to the eastern half or two-thirds of the valley; and the succeeding Little Oak is found only in one or two of the eastern troughs in Alabama.

In Black River time that excellent datum plane—the Lowville and its red sandy facies, the Moccasin or “Bays”—began a new series of alternating tiltings in which the southern invasions predominated. The Lowville, itself, extends from the Mississippi River far eastward to East Tennessee and in places there overlaps the Chazyan formations quite to the edge of the overthrust Lower Cambrian formations. To the north in the middle stretch of the valley the Chambersburg, which invaded from the northeast and follows the Lowville, extends southwardly from Pennsylvania to Lexington, Va., beyond which place it has not been recognized. Usually, and perhaps throughout its extent, the Chambersburg is succeeded by the shaly lower Martinsburg facies of the Trenton. In the belt just within the western side of the valley, in which it is represented by its typical limestone facies, the Trenton is succeeded by either the Reedsburg shale phase of the Cincinnati or by distinguishable Eden and Maysville formations. In the

southwestern corner of Virginia the Maysville is represented only by its lower formation (the Fairview). At Cumberland Gap and to the south in Sequatchie Valley this is succeeded directly by the Sequatchie formation, which is the southern Appalachian marine equivalent of the Richmond. Following the strike northeastward from Cumberland Gap up the Powell Valley the Sequatchie loses in thickness and probably disappears entirely before reaching Big Stone Gap, so that younger Medinan and finally Clinton beds are in contact with the Fairview.

In the Clinch River Valley belts to the southeast the Richmond is represented by the nonfossiliferous red, probably continental deposit known as the Juniata sandstone. This extends continuously from northeastern Tennessee to central Pennsylvania and thence under cover to western New York, where it is known as the Queenston shale or sandstone. In central Pennsylvania and New York the Juniata and Queenston are underlain by the Oswego ("Gray Medina"), sandstone, also mainly a continental deposit, that is believed to correspond in age with the highly fossiliferous McMillan formation of the Cincinnati section. The Brassfield and Whiteoak represent southern marine invasions that reached the Appalachian Valley only south of Virginia and also only in places that had been occupied previously by the Sequatchie. The Tuscarora and the at least partly equivalent Clinch sandstone rest on the Juniata and like it are unfossiliferous and regarded as continental deposits that in their case correspond in age to the fossiliferous Brassfield and Whiteoak formations which occur in belts to the west of Clinch Mountain. No indication of important movements having occurred during the transition from the Lower to the Upper Medina or, in other words, between the Richmond and Alexandria (or "Albion"), epochs has been observed in the Appalachian Valley region between the Adirondacks and central Alabama.

North Appalachian Valley.—This column pertains mainly to the Ordovician and early Silurian deposits in Newfoundland, Anticosti, and the St. Lawrence and Champlain valleys. The Canadian and Ozarkian formations in this region are not referred to except to state my opinion that zones F, G, and H of the Newfoundland section are of Upper and perhaps Middle Canadian age and that the Ozarkian is represented at Philipsburg, Quebec, by beds of the Upper and the Lower series. To this I may add the further opinion that the sections in northern Vermont and at Philipsburg, Quebec, do not include deposits of Middle Ozarkian age; and in the latter section only one of the Champlain Valley Beckmantown formations, namely, the Cassin limestone, has been recognized. Regarding the Chazyan

formations further comment is regarded as unnecessary because the statement and braces on the chart give a sufficiently clear illustration of my belief that the formations and zones of this age in the northeastern St. Lawrence extension of the Appalachian Valley region fall between rather than opposite the formations in its southern part (see pp. 57 and 76). The Lowville and the in part sandy shales (Snake Hill, Canajoharie, and Schenectady), that are correlated with the lower half of the Martinsburg occur in the Champlain and lower Mohawk valleys. The Richmond, Alexandria, and Clinton formations at the top of the column occur on the Island of Anticosti.

In 1923⁸⁷ I referred the Gun River formation of the Anticosti section to the Lower Clinton. This was done on unimpeachable fossil evidence found on slabs that had been sent by Doctor Twenhofel to Doctor Bassler for report on the Bryozoa and Ostracoda and which were marked as collected by the former in the Gun River formation. Twenhofel's final report⁸⁸ on the "Geology of Anticosti Island" now being at hand it appears that these supposed Gun River fossils were either incorrectly labeled or the beds from which they were collected were subsequently assigned to the lower part of the Jupiter River formation. Despite the elimination of these unquestionably Lower Clinton fossils review of the revised lists of Gun River fossils in Twenhofel's last report still leaves considerable and perhaps sufficient ground for my 1923 view. At present, therefore, I will modify it only so far as to say that the Gun River is mainly and perhaps entirely of Clinton age. The underlying Bessie I regard as either contemporary with the Brassfield or slightly older but not as old as the Edgewood of Missouri and southern Illinois. The Ellis Bay falls somewhere between two or opposite one of the three or four Upper Medinan formations that underlie the Brassfield in the Mississippi Valley. Partly to indicate the uncertainty of these correlations—but mainly because alternate arrangement of the units accords with my view that, as a rule, formations in the eastern part of the St. Lawrence trough are not precisely correlatable with those of nearest dates in interior basins—the Gun River is placed midway between the Clinton and the Brassfield and the Bessie just beneath the space allotted to the Brassfield.

Britain.—This column begins with the Tremadoc, which I believe belongs rather low in the Canadian and may be correlated in general with the *Dictyonema flabelliformis* zone of the Bretonian of Matthew and the Schaghticoke shale of eastern New York. The Shineton

⁸⁷ Ulrich, E. O., and Bassler, R. S., American Silurian formations: Maryland Geol. Survey, Silurian vol., pp. 368-372.

⁸⁸ Geol. Survey Canada, Mem. 154, 1928 (title page reads 1927).

seems to be nearly of the same age, but the Arenig, which succeeds it, is more confidently assigned to the Upper Canadian. The Durness on the northwest coast of Scotland belongs to another province and is closely related to American formations of the Canadian. Its lower part contains the *Lecanospira* fauna, which characterizes the Middle Canadian in the Appalachian Valley, Missouri, Oklahoma, Texas, and many areas in western North America; and its upper half contains the similarly distributed *Ceratopea* fauna which is equally characteristic of the Upper Canadian. So far as known the Durness comprises only Middle and Upper Canadian. In this respect it agrees with the Canadian as developed in Missouri and northern Arkansas and in Alabama, Tennessee, and most of the valley in Virginia. The lower Canadian series is differently and less widely distributed. In the Mohawk Valley in New York and probably also in New Jersey no higher beds of the system are present. However, in the vicinity of Ticonderoga, N. Y., again in central and southern Pennsylvania, and thence southward through Maryland to some unknown point in northern Virginia, and finally in the Arbuckle and Wichita uplifts in Oklahoma the Middle and Upper Canadian limestones are underlain by varying thicknesses of the lower series. The observed maximum of 3,000 feet (Jonesboro limestone), is attained at Limestone, Tenn. The section at this place is further unusual because the excellently exposed Jonesboro limestone is directly succeeded by a 50-foot development of Lenoir limestone and this by Athens Shale.

A small variety of *Didymograptus bifidus* is said to occur in the basal part of the Llandeilo. In America we have two small varieties of this graptolite, and both occur near the boundary between the Canadian and the Ordovician. One occurs in Lawrence County, Arkansas, near the top of the Black Rock limestone, which is the youngest of the Canadian formations in the Mississippi Valley. The other occurs near the base of the Joins limestone with which the Ordovician (Ulrich), begins in Oklahoma. Which of the two is most like the Llandeilo variety remains to be determined.

SUPPLEMENTARY NOTES ON THE GIRVAN DISTRICT SECTION

In deference to my belief that the Ordovician formations of the Girvan District named in the middle part of this column are with two exceptions not strictly correlatable with Appalachian formations, I have placed the names of most of them in midway positions with respect to those of the latter. The following notes on the Girvan section, which became possible only since my visit to Girvan the past summer with Prof. O. T. Jones and other British and American members of the Princeton University Summer School of Geology in

Britain, seem more appropriate here than in preceding parts of the paper.

The Stinchar limestone of the type locality rests on the Kirkland conglomerate which presumably represents the elastic initial deposit of the Stinchar stage of submergence. The conglomerate rests—doubtless unconformably—on Radiolarian cherts and black shales said to contain Arenig (Upper Canadian) graptolites.

Lithologically and to notable extent also faunally the upper part of the typical Stinchar is strikingly like the upper part of the Lenoir limestone in Tennessee and Virginia, a fact observed and commented on by Professor Jones when we studied the natural outcrop of the formation and its unweathered appearance in the quarry. The lower part of the Stinchar also resembles lower beds of the Lenoir, so that as a whole the formation strongly suggests approximate equivalence to the mentioned American formation.

The limestone exposed in the quarry at Craighead, about 3 miles east of Girvan and which supplied many of the distinctive fossils of the district, is generally classed as Stinchar limestone. But this correlation is almost certainly in error. The supposed age equivalence of the Craighead and Stinchar limestones evidently arose from the fact that Lapworth in describing the section at Craighead regarded the limestone in the quarry as being succeeded normally by a shale formation from which he had collected Glenkiln graptolites. In other words, Lapworth decided that the sequence at Craighead is the same as on the Stinchar where shale of Glenkiln age lies in normal sequence on the typical Stinchar limestone.

I doubt that any of our 1929 party left the Craighead quarry unconvinced that the well displayed superposition of the shale on the limestone in the quarry is due to overthrust faulting and not original deposition—namely, that the Glenkiln shale has been thrust over a much younger, probably Medinan, limestone formation. All agreed, too, that the Craighead limestone is very different in lithic and faunal characters from the previously investigated typical Stinchar. So far as I have been able to learn not a single species of fossils is common to the limestones of the Craighead and the Stinchar. Besides, the published fauna of the typical Stinchar makes but a short list, whereas a total of at least 85 species has been collected from the Craighead quarry limestone.

The relations of the Craighead limestone fauna to that of the Balclatchie group is much closer. In fact, of the 85 Craighead fossils Reed's lists of Girvan fossils described in his monographs indicate that 37 of the trilobites and brachiopods are present also in the Balclatchie beds. It should be noted, however, that with very few exceptions Reed expresses some doubt regarding the actual specific identity

of the species listed as common to the Balclatchie and the Craighead limestone. The latter, of course, is referred by him to the Stinchar, and its fossils are listed under that heading. Comparison of Reed's lists therefore indicates a much greater similarity in the fossil contents of the Stinchar and Balclatchie formations than is warranted by the facts. Indeed, I am confident that revision and correction of the lists will show that not a single species of the true Stinchar passes upward into the Balclatchie.

Evidently the Craighead fauna comprises a large proportion—approximately 40 per cent—of derivatives of Balclatchie species. Many of these may be very close relatives that as preserved are not readily distinguishable from their ancestors. However, experience shows that with good and abundant material and closer attention to details of structure these difficulties of discrimination will become much less and in most instances quite ordinary. Moreover, this similarity of faunas is precisely what should be expected and what we are experiencing over and over again in comparing faunas that invaded from the same sea at more or less widely different times.

The Balclatchie, despite the mentioned faunal similarity to the Craighead, is unquestionably Ordovician in age. The only question is how far beneath the top of the American development of the system does it belong? In my opinion the Balclatchie, together with the Benan conglomerate which I regard as the initial deposit of its time, is not older than the Tellico of east Tennessee and both most probably are entirely post-Blount age. The Ardwell Group then may be placed near the middle of the Black River Group. I have recently procured what seems good faunal and physical evidence for this view in northern Virginia, but more field work and further study of the fossil collections is desired before I shall feel prepared to discuss the problem.

In the case of the Whitehouse group positive faunal evidence tending to show its stratigraphic relations to Appalachian formations is as yet scant and far from conclusive. However, taking into account all of the faunal similarities now supposed to have any bearing on the question together with probabilities suggested by the lithic character of underlying and overlying formations in Girvan, we may be safe in placing the Whitehouse within the limits of the Trenton group or perhaps at the contact of the Trenton and Eden groups. After this disposal of the Whitehouse and the more confident reference of the Drummuck to the Medinan the intervening Barren flagstones seem to fall very naturally into the space occupied in America by the Upper Cincinnati (Maysville group). The Girvan beds supposed to be of this age agree particularly well with the upper part of the Pulaski group and the Oswego sandstone as developed in parts of New York and Pennsylvania.

THE ASHGILLIAN OF NORTHWESTERN ENGLAND

Marr's term Ashgillian does not appear on the chart, but since I enjoyed an opportunity the past summer to study the typical and best known exposures of the series in northwestern England under the able guidance of T. C. Nicholas and W. B. R. King, both of Cambridge University, some expression of my opinion concerning the age of the beds covered by the term seems desirable. As defined by Marr³⁹ and as the beds and fossils appeared to me in the field, the Ashgillian should fall within the Medinan epoch. Whether any part of the series is of Richmond age I am not prepared to say, but the upper part at least I am strongly inclined to refer to the Alexandrian.

Let me say further that at no place visited by us in 1929 did we see any convincing contact between beds admitted by our guides to be very low Silurian and beds of Ashgillian age that my British friends classify as "Upper Bala" or "Caradocian" and therefore as "late" Ordovician. The supposed "contacts" and sometimes "passage" beds that were pointed out as marking the transition from the Ordovician to the Silurian in no case presented the diastrophic criteria and qualities that in America we insist on being definitely located in the outcrop and indubitably shown to be present at the Ordovician-Silurian contact. However, much more convincing and diastrophically well marked contacts occur in the Lakes District and elsewhere in Britain between lower beds, but as their fossils consist mainly of Ordovician generic types and perhaps particularly because they lack monograptids they are referred by the British geologists to the Ordovician system.

In my opinion the naturally defined base of the Silurian in the English Lakes District lies at the base of the Coniston limestone series. This series begins with the "Stile End beds," 0 to 50 feet thick and consisting of sandstones, grits, and as much as 10 feet of coarse conglomerate at the base. The Stile End beds are succeeded by the Applethwaite beds—calcareous shales, banded and nodular limestones—about 100 feet thick, with a basal zone full of pebbles derived from the underlying Borrowdale volcanic series. Here and there the Applethwaite limestone is highly fossiliferous, the fauna consisting mainly of corals. But these corals—among them several species of *Heliolites*—are of kinds that viewed in the light of American occurrences could indicate nothing older than topmost Medina or Clinton. The Applethwaite is succeeded by Marr's Ashgill group, 70 feet thick, with the *Phillipsinella* beds at the base and the *Phacops mucronatus* beds—now admitted by Troedsson to be Silurian—in

³⁹ Marr, J. E., The Lower Paleozoic rocks of the Cautley District: Geol. Soc. London Quart. Journ., vol. 69, p. 5, 1913.

the middle third. The Ashgillian is succeeded by the Skelgill beds. These comprise a number of thin zones with species of *Monograptus* and at the base a thin limestone with *Atrypa flexuosa* and directly over this a black mudstone with *Dimorphograptus*.

Just why the first appearance of monograptids, unheralded as it usually is by a well-marked physical break, should determine the beginning of the Silurian system and the close of the Ordovician is not clear to me. It is merely an event in the course of Silurian history and one that can hardly be expected to have been manifested at precisely the same time everywhere. It is no more important than the first appearance of *Fenestella* in the Richmond or of *Hemitrypa* in the Brassfield or of *Coelospira* and *Spirifer* in the Clinton or of the subsequent first appearances of many other generic types that became abundant and lasted for long periods thereafter.

In America we also find it troublesome to detect a satisfactory physical or faunal boundary between the Richmond and the Alexandrian, and considerable difference of opinion as to the precise location of the Medinan-Clinton boundary is notable in American literature. However, as regards the systemic boundary, the best informed American stratigraphers—at least those who have learned their stratigraphy from field observations in many areas rather than from laboratory studies and comparisons of collections of fossils—are well satisfied to follow the footsteps of the geologists of the first geological survey of New York, who in the forties of the last century drew the boundary between their Ontario and Champlain divisions of the New York system at the generally clearly marked base of the Lower Medinan. The official survey of New York has never, so far as I know, receded from its position on this question except by substituting British terms for New York names.

After four brief but well-filled periods of field studies in Britain, Scandinavia, and Bohemia my conviction that diastrophically well-marked systemic boundaries essentially corresponding in age to those worked out in America may also be determined on the east side of the Atlantic is more firmly fixed than it was on my first visit to Europe in 1922.

Norway and Sweden.—This column requires little explanation. Etage 5 of the Norwegian section and the Leptaena limestone of Sweden are placed into the Silurian for practically the same reasons as those that seemed to demand the removal of the British Keisley and Drummuck formations from the Ordovician to the naturally delimited Silurian system advocated by me. The proper placing of the Norwegian Etage 4 and the Swedish *Trinucleus* (*Tretaspis*) and *Chasmops* zones I find much more difficult. Regarding these Scandinavian zones the *Trinucleus* zone seems at present to belong

high in the Ordovician—perhaps within the broader zone of the American *Viola* limestone, though the *Trinucleidae* in the two are quite different. The half dozen species in the latter are of *Cryptolithus*, whereas those in the Swedish formation are of *Tretaspis*. One of the latter is identified with *T. bucklandi*, a Drummuck species in Scotland, which according to preceding argument (pp. 61–69) is early Silurian rather than late Ordovician. But the *Viola* also is not firmly fixed in the position given it on the chart. We know only that it is younger than Trenton and in unconformable contact with the Fernvale above. It may therefore correspond to the whole or to some part of the Cincinnati, or, if it does not belong between the Eden and the Maysville, its place may be in the hiatus between the Maysville and the base of the Richmond. The fauna gives no conclusive indication whatever, and what evidence it does present seems to favor the last interpretation rather than the others. If the *Trinucleus* zone proves older than the *Viola* the position of the underlying *Chasmops* will also be lowered in the scale.

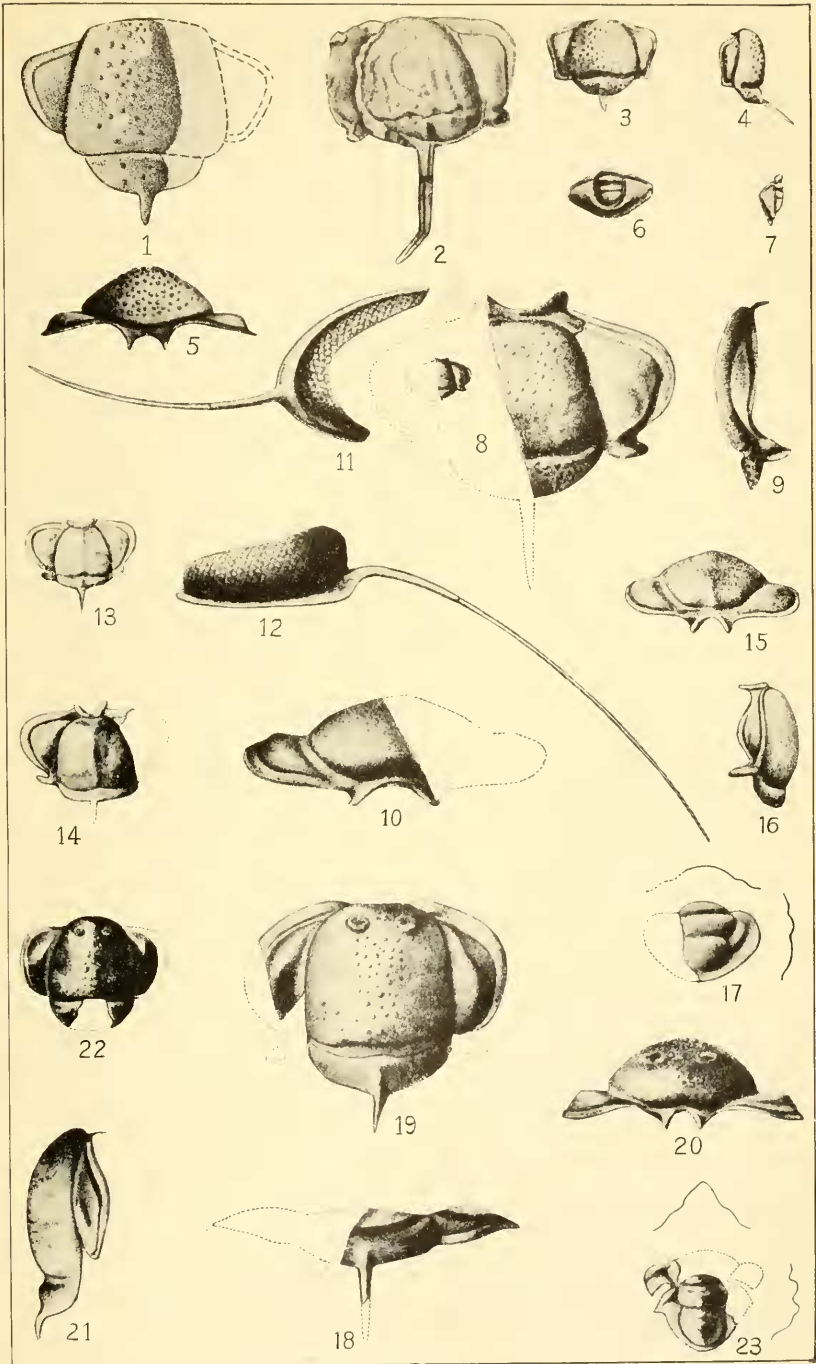
Etage 3° (*Orthoceras* limestone) probably is older than given on the chart. A positive statement is not yet warranted, but judging from its fossils I am inclined to believe that eventually Etage 3° and the Kunda of the Baltic Province will be found to correspond to our Buffalo River series.

Baltic region.—Above the Wesenberg no material change has been made from the correlations indicated in the table published in my 1926 paper on the Ordovician-Silurian boundary. The Borkholm is again correlated with the Leptaena limestone of Sweden and the Keisley of England, and all three are placed in the general horizon of the Upper Medinan. The Lyckholm, also, is referred as before to the Richmond. More doubt is entertained regarding the position of the Wesenberg and also as to the stratigraphic relations of the Kegel and the four members of the Wierland group of Raymond to Ordovician formations of America. A somewhat lower position is suggested for the latter than in the preceding paper; but I am not certain that the present arrangement is nearer the truth than the other. On the other hand, I can not free my mind of the suspicion that most if not all of these east Baltic formations were not deposited at strictly the same times as those in either of the Scandinavian countries or those in England, Scotland, and Ireland or those in North American areas, with which they have hitherto been more or less confidently correlated by others as well as by me.

EXPLANATION OF PLATES

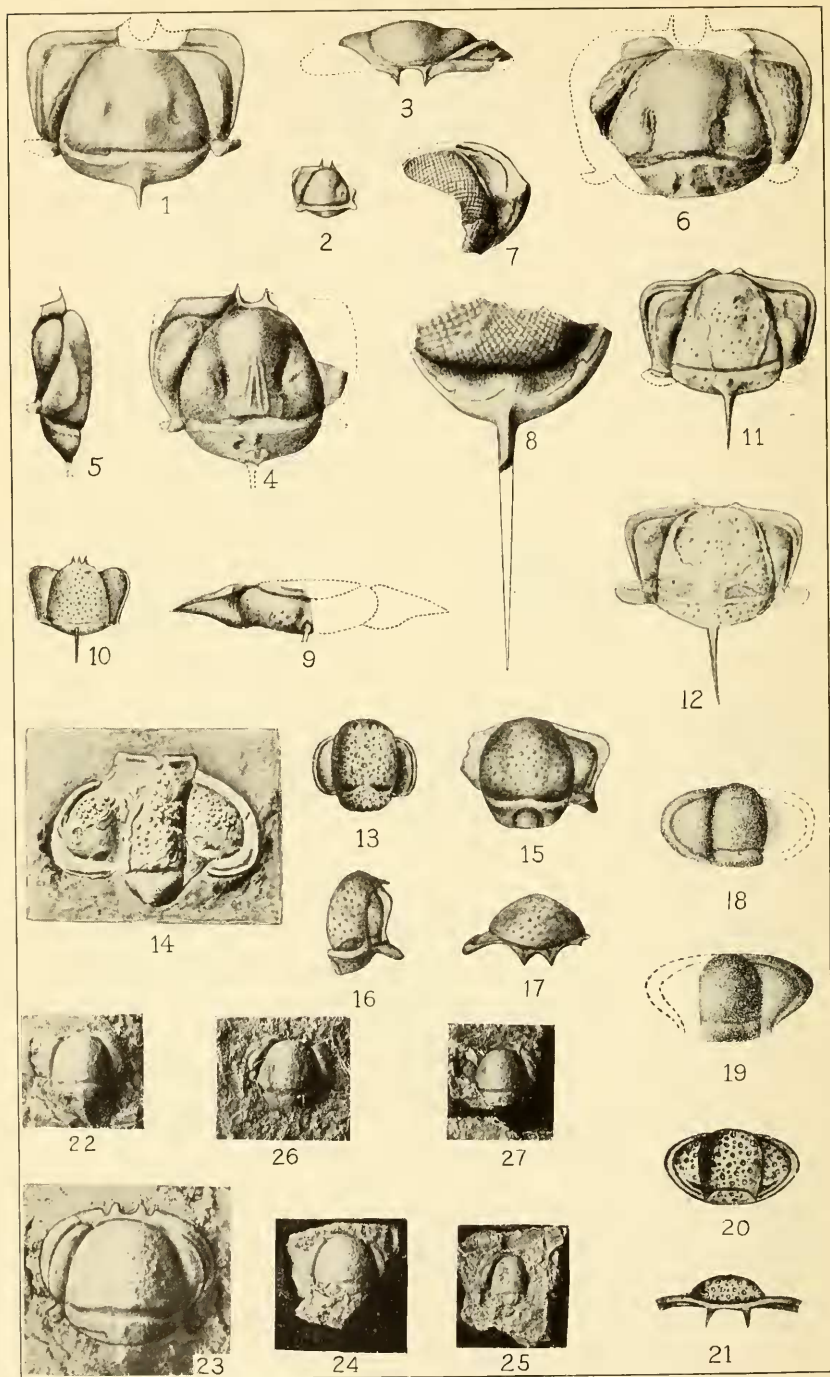
PLATE 1

	Page
FIG. 1. <i>Telephus reedi</i> , new species.....	19
Copy of Reed's figure of the cranidium of this Girvan species that he had referred, probably erroneously, to <i>T. fractus</i> Barrande; $\times 3$. Whitehouse group, Girvan District, Scotland.	
2. <i>Telephus</i> species undetermined:	
Copy of Hadding's figure of a small specifically undetermined cranidium of this genus, $\times 5$. Compare <i>T. spiniferus</i> and <i>T. wegelini</i> . Lower Dicellograptus shale near Röstånga, Sweden.	
3-7. <i>Telephus fractus</i> Barrande.....	10
Copies of Barrande's illustrations of this species; all natural size except fig. 5, which is $\times 2$. Etage, D ₄ , Lodewitz and Koenigshof, Bohemia.	
8-10. <i>Telephus jamtlandicus</i> , new species.....	13
8. Imperfect cranidium, $\times 1$ and $\times 4$, that is provisionally distinguished under this name from the other specimens figured and referred, apparently in error by Hadding to <i>T. bicuspis</i> Angelin. Copied from Hadding.	
9, 10. Side and anterior views of same, $\times 4$. Lower part of Ogygiocaris shale, Jämtland, Sweden.	
11-18. <i>Telephus haddingi</i> , new species.....	12
11, 12. Different views of free cheeks with eyes, $\times 9$. 13, 14. Dorsal views of two cranidia, $\times 2$. 15, 16. Anterior and sideviews of a larger cranidium, $\times 2$. 17. Imperfect pygidium, with transverse and longitudinal pro- files, $\times 6$. 18. Incomplete thoracic segment, $\times 5$. Figures copied from Hadding's paper in which these specimens are referred to <i>T. bicuspis</i> . For copies of Angelin's figures of the Norwegian types of his <i>T. bicuspis</i> see pl. 2, figs. 20, 21. Lower part of Ogygiocaris shale, Jämtland, Sweden.	
19-23. <i>Telephus granulatus</i> Angelin.....	11
Copies of Hadding's figures of Swedish specimens of cranidia and a pygidium referred by him to this species. The two cranidia seem to differ slightly and neither is quite like Angelin's figure of the Norwegian type of the species. For copy of the latter see pl. 2, fig. 13. Upper part of Ogygiocaris shale, Jämtland, Sweden.	



ORDOVICIAN TRILOBITES OF THE FAMILY TELEPHIDAE

FOR EXPLANATION OF PLATE SEE PAGE 90

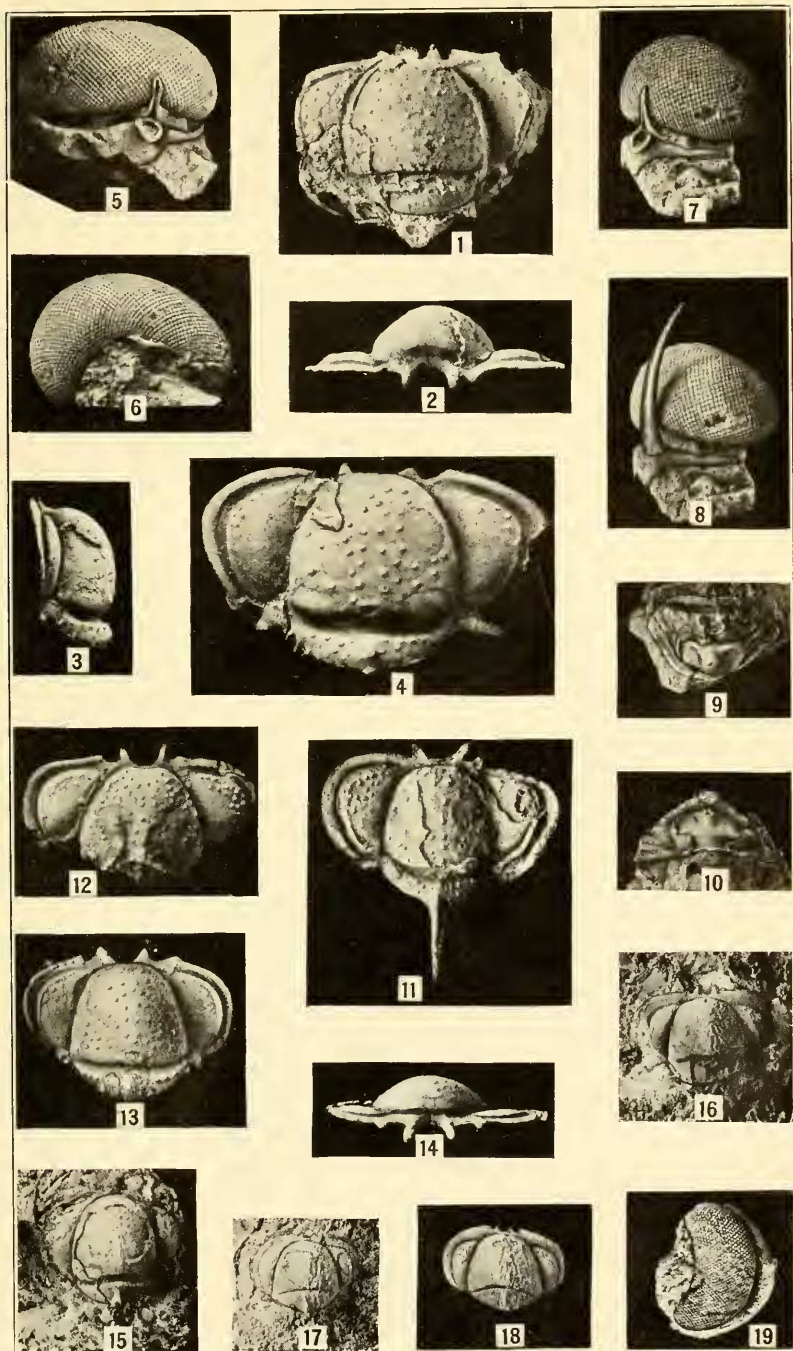


ORDOVICIAN TRILOBITES OF THE FAMILY TELEPHIDAE

FOR EXPLANATION OF PLATE SEE PAGE 91

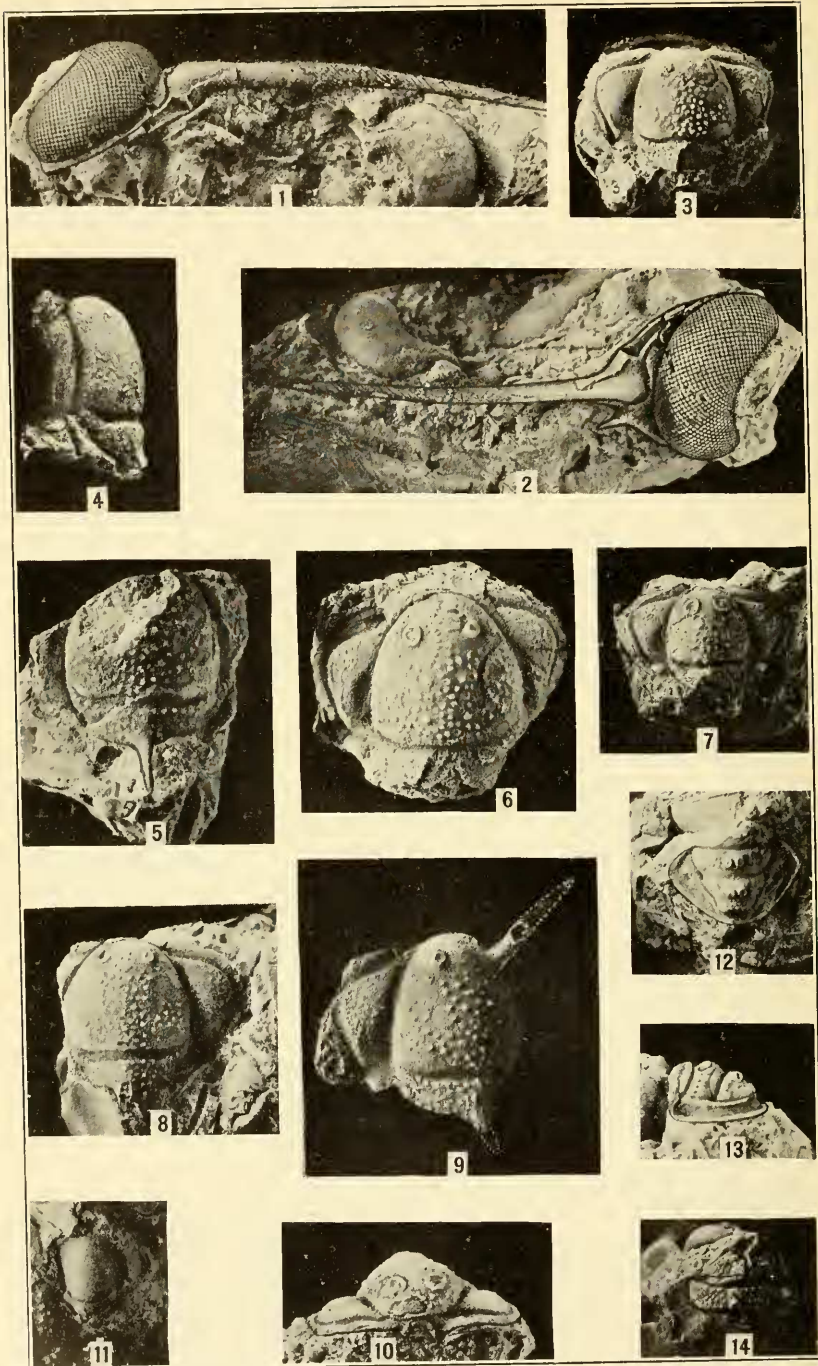
	Page
Figs. 1-9. <i>Telephus mobergi</i> Hadding	14
1. A small cranium, $\times 4$.	
2. Dorsal view of another cranium, $\times 1$.	
3-5. Anterior, dorsal and side views of same, $\times 3$.	
6. Dorsal view of a large cranium, $\times 3$.	
7, 8. Free cheeks with broken eyes, $\times 3$ and $\times 5$.	
9. Half of a thoracic segment, $\times 3$.	
Copies of original figures in Hadding's paper. Basal beds of the Ogygiocaris shale, Jämtland, Sweden.	
10-12. <i>Telephus wegelini</i> Angelin	13
10. Copy of Angelin's original figure of the cranium of this species. The middle spine shown in front doubtless is a misapprehension.	
11, 12. Copies of Hadding's figures of two crania, $\times 3$. Black Trinucleus shale, Dalarne, Sweden.	
13. <i>Telephus granulatus</i> Angelin	11
Copy of Angelin's figure of the type of this species.	
14. <i>Telephus</i> ? <i>salteri</i> Reed	20
Copy of Reed's dorsal view of the type of this strange species. As given by Reed, the greatest width of this cranium is 5.4 mm.	
Balclatchie group, Balclatchie, Girvan District, Scotland.	
15-17. <i>Telephus linnarssoni</i>, new species	15
Dorsal, side and front views, $\times 3$, of the holotype of this species; after Warburg.	
Leptaena limestone, Boda, Dalarne, Sweden.	
18, 19. <i>Telephus hibernicus</i> Reed	17
Copies of figures of two crania of this species, $\times 4$, after Reed. The lower figure suggests shortening by compression.	
Tourmakeady Beds, County Mayo, Ireland.	
20, 21. <i>Telephus bicuspis</i> Angelin	12
Copies of Angelin's original figures of this species. (See also pl. 1, figs. 11-18).	
22-27. <i>Telephus americanus</i> Billings	21
22, 23. Dorsal views, $\times 2$ and $\times 4$, of the selected holotype of this species. The figures given by Hadding were made from a plaster cast of this specimen. It seems also to be the one from which Billings' illustration was prepared.	
24, 25. Two other crania, the second not completely uncovered, $\times 2$, that agree very closely with the holotype.	
26. A fourth cranium, $\times 2$, that differs enough in the shape of the glabella to suggest a distinguishable species or variety.	
27. Probably another cranium of the preceding variety, $\times 2$. Probably Upper Chazy (Div. N and P), Newfoundland.	

FIGS. 1-10.	<i>Telephus pustulatus</i> , new species.....	Page 28
	1. Dorsal view of a cranium, $\times 3$. U.S.N.M. No. 80536a.	
	2, 3. Front and side views of the holotype cranium, $\times 3$. U.S.N.M. No. 80536.	
	4. Dorsal view of same, $\times 4$.	
	5-7. Different views of a free cheek, all $\times 4$, showing its small rim, very large eyes, and the broken base of the genal spine. U.S.N.M., No. 80536b.	
	8. Same view as figure 7 with genal spine restored.	
	9, 10. Dorsal and end views of pygidium, $\times 4$. U.S.N.M., No. 80536c.	
	Whitesburg limestone, Lexington, Va.	
11.	<i>Telephus spiniferus</i> , new species.....	29
	Dorsal view of the holotype cranium, $\times 4$. U.S.N.M. No. 80537. Basal 20 feet of the Athens shale, over large Holston limestone quarry, 3 miles southeast of Saltville, Va.	
12.	<i>Telephus spiniferus calhounensis</i> , new variety.....	30
	Dorsal view of the imperfect cranium, $\times 4$, on which this variety of species is based. Holotype, U.S.N.M. No. 80538. As will be observed, it differs from the holo- type of the older typical form of the species in the shape and, apparently also, in the furrowing of the glabella. Athens shale, 75 feet beneath top bluff of Hi- wassee River, one and a half miles east of Calhoun, Tenn.	
13, 14.	<i>Telephus latus</i> , new species.....	26
	Dorsal and anterior views of the holotype, $\times 3$. The species resembles <i>T. pustulatus</i> but differs in the outline and lesser convexity of the glabella and the general flatness of the fixed cheeks. U.S.N.M. No. 80539. Thin limestone lenses in the basal 20 feet of the Athens shale, at quarry southeast of Saltville, Va.	
15	<i>Telephus sinuatus</i> , new species.....	30
	Dorsal view of holotype cranium, $\times 4$. Glabella some- what as in <i>T. spiniferus</i> but fixed cheeks much narrower. U.S.N.M. No. 80540. Whitesburg limestone, Lexington, Va.	
16-19.	<i>Telephus prattensis</i> , new species.....	34
	16. Dorsal view of a cranium from Pratts Ferry, Ala., $\times 3$. Cotype U.S.N.M. No. 80541.	
	17, 18. Similar views, $\times 3$, of two cranidia from the Whitesburg limestone, 1 mile south of Bulls Gap, Tenn. Cotypes U.S.N.M. No. 80542.	
	19. Free cheek, $\times 4$, associated with this species and <i>T. bipunctatus</i> at Pratts Ferry, Ala. U.S.N.M. No. 80541a.	



ORDOVICIAN TRILOBITES OF THE FAMILY TELEPHIDAE

FOR EXPLANATION OF PLATE SEE PAGE 92



ORDOVICIAN TRILOBITES OF THE FAMILY TELEPHIDAE

FOR EXPLANATION OF PLATE SEE PAGE 93

PLATE 4

Page
23

FIGS. 1-14. *Telephus bicornis*, new species-----

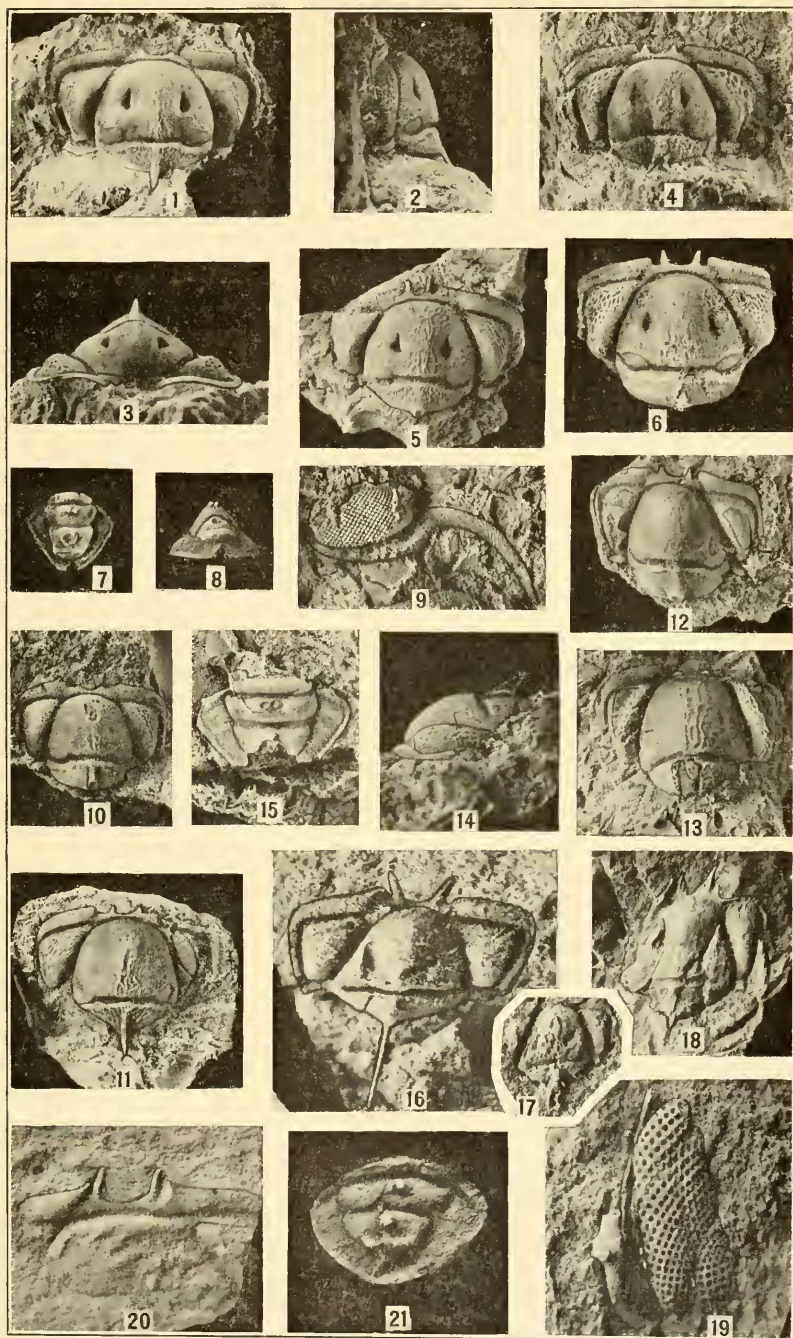
- 1, 2. Anterior and dorsal views of a free cheek, $\times 4$. The latter shows the shorter spine behind the longer one which is regarded as the real genal spine. U.S.N.M. No. 80535a.
3. Dorsal view of rather small cranidium, $\times 3$. U.S.N.M. No. 80535b.
4. Side view of a larger cranidium, $\times 3$. U.S.N.M. No. 80535c.
5. Dorsal view of an imperfect cranidium with occipital spine complete, $\times 3$. U.S.N.M. No. 80535d.
6. Large cranidium somewhat crushed in right anterior third, $\times 3$. U.S.N.M. No. 80535e.
7. Nearly complete but small cranidium, $\times 3$. U.S.N.M. No. 80535f.
8. Another cranidium, $\times 3$. U.S.N.M. No. 80535g.
9. Still another cranidium that retains about half of one of the glabellar spines, $\times 3$. The specimen was tilted in photographing so as to show the full length of the remaining part of the right spine. U.S.N.M. No. 80535h.
10. Anterior view, $\times 4$, of the specimen shown in Figure 7.
11. An associated hypostoma supposed to belong to this species, $\times 3$. U.S.N.M. No. 80535i.
- 12-13. Respectively dorsal and side views of the associated pygidium, $\times 3$. U.S.N.M. No. 80535j.
14. One of the thoracic segments, $\times 3$. U.S.N.M. No. 80535k. All these specimens are regarded as cotypes of the species, and all were collected from a single ledge of Whitesburg limestone, 5 miles southwest of Bland, Va.

- Figs. 1-9. *Telephus bipunctatus*, new species-----
- 1-3. Dorsal, lateral, and anterior views of a nearly perfect cranium, $\times 4$. U.S.N.M. No. 80543a.
- 4-6. Dorsal views of three other crania, $\times 4$, selected to show extremes of observed variations in shapes of parts and in surface sculpture. U.S.N.M. No. 80543b.
- 7, 8. Dorsal and posterior views of a pygidium, $\times 4$. Only the broken bases of the double-headed spines on the axial rings are retained when the specimens are uncovered in breaking the limestone matrix. U.S.N.M. No. 80543c.
9. The most complete of the free cheeks, $\times 4$. U.S.N.M. No. 80543d.
- Whitesburg limestone, Lexington, Va. All these specimens may be ranked as cotypes of the species.
- 10-15. *Telephus impunctatus*, new species-----
- 10-13. Dorsal views of four crania, $\times 3$, that may be regarded as cotypes of the species. U.S.N.M. No. 80544. The specimen of Figure 12 has been slightly distorted by obliquely transverse pressure.
14. Side view of Figure 13.
15. Pygidium associated with these crania, $\times 4$. It is wider and the axis less convex than in *T. bipunctatus* which occurs in the same bed and place. U.S.N.M. No. 80545.
- Whitesburg limestone, near Albany, Tenn.
16. *Telephus buttsi*, new species-----
- One of three very small crania, $\times 8$. All of these have been similarly shortened by compression. Their general aspect suggests *T. bipunctatus* and *T. troedssoni*, but the occipital spine is too long, slender, and round for either of those species. They remind also of *T. mobergi*, but the occipital spine is too long and the fixed cheeks too wide to warrant their reference to that species. U.S.N.M. No. 80546.
- Yellow, leached shale, at base of the Athens shale, near Longview, Ala.
- 17-21. *Telephus troedssoni* Raymond-----
17. Dorsal view of a clay impression taken from the holotype of this species, $\times 3$. The latter is a natural mold of the exterior of an imperfect cranium, somewhat distorted by compression in slightly oblique direction. Original in Mus. Comp. Zoöl., Cambridge, Mass.
- Near base of Athens shale, near Athens, Tenn.
18. An imperfect and distorted cast of the interior of a cranium supposed to belong to this species. The middle part of the anterior border is well preserved and clearly shows the distinctness of the median anterior pair of spines and the shorter spines to which the ends of the free cheeks are joined. U.S.N.M. No. 80547.
19. An associated cast of the interior of a free cheek with compound eye, $\times 8$. U.S.N.M. No. 80547a.

33

40

40



ORDOVICIAN TRILOBITES OF THE FAMILY TELEPHIDAE

FOR EXPLANATION OF PLATE SEE PAGES 94 AND 95

FIG. 20. Another cast of the interior of a cranidium found with the preceding two specimens, $\times 8$, more doubtfully referred to this species. This has been greatly shortened by pressure and is otherwise imperfect. It is figured mainly because it retains most of the anterior border and shows the separateness of the median pair of spines even in this form, in which their bases are very close to the anterior ends of the facial sutures. U.S.N.M. No. 80547b.

21. A pygidium found with the preceding, $\times 8$. Though somewhat shortened by compression, it still shows a greater width of border than is found in other species. In general it reminds most of the pygidium assigned to *T. impunctatus*. U.S.N.M. No. 80547c.

All found with *T. buttsi* in the basal part of the Athens shale, 1.5 miles northeast of Longview, Ala.